VOLUME XLVI NUMBER 1 WHOLE 399

SCHOOL SCIENCE AND MATHEMATICS

JANUARY 1946

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis.

PRICE. Two Dollars and Fifty Cents a year; foreign countries $3.00; current single copies 35 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.

Those who have had long experience in education recognize that new things are learned slowly and retained only after repeated use.—OVID W. ESHBACH.

CONTENTS FOR JANUARY, 1946

SCHOOL SCIENCE AND MATHEMATICS

VOL. XLVI JANUARY, 1946 WHOLE NO. 399

THE SIGNIFICANCE OF ATOMIC ENERGY

H. B. HASS
Purdue University, Lafayette, Ind.

The most devastating explosion in the history of the world on August 5, 1945 announced the most important scientific discovery of all time, the controlled release of atomic energy. Since then newspapers, magazines, and radio commentators have been busy with explanations and interpretations but, in my opinion, it will take many thousands of years to realize fully the consequences of what happened at Hiroshima. We are conscious already of a great deal of difference of opinion as to whether or not this was a good thing; some are calling the new weapon barbarous and inhumane, others say that it will usher in a new era of human progress in contrast to which all previous civilizations will seem primitive.

My views are here presented not because I feel myself to be wiser than others who are speaking and writing on the subject but because I have been thinking about it longer than many of them. In the spring of 1942 I was called in as a consultant on the Manhattan project and on July 1 was appointed official investigator. Since then we have had at Purdue a total of ninety-six men and women in the Department of Chemistry working on a contract with the Manhattan District under the immediate direction of one of our most brilliant, young, research professors, Dr. E. T. McBee. The project was given top priority and professors were somewhat unceremoniously forced to move into smaller quarters without our even being able to tell them what it was all about until after August 5.

The development of the weapon really began forty-nine years ago with the discovery by Becquerel, a Frenchman, that photographic plates lying in a drawer near a sample of uranium ore became gradually fogged. Marie Curie, a Polish woman, and her husband Pierre, a Frenchman, then proceeded to discover radium and the phenomenon of radioactivity by which is meant the spontaneous disintegration of atoms. It was evident that enormous quantities of energy are involved in this process and the Einstein theory was in part an effort to explain this fact. In ordinary language, the Einstein equation states that the complete destruction of one pound of matter releases more than ten billion kilowatt hours of energy. It is said when the Einstein theory was first formulated that not more than twenty persons in the whole United States were sufficiently trained in Riemannian geometry to understand it. You may remember the limerick

> There're some marvelous people named Stein
> There's Gertie, there's Ep and there's Ein
> Ep's statues are junk
> Gert's verses are bunk
> And nobody understands Ein.

On the principle that what you don't understand is probably of no great importance, most people ignored Einstein but mathematical physicists applied the relativity concept with great success to their problems. Einstein was a German Jew.

During World War I, Sir Ernest Rutherford, a Britisher, refused to work on anti-submarine devices because he was trying to split atoms and believed that if he succeeded the result would be more important than the war. He succeeded on a very small scale.

In 1932, James Chadwick, another Britisher, discovered the neutron, a unit particle of mass equal to a hydrogen atom but with no electric charge. The absence of charge enables it to penetrate the screen of electrons which surrounds the positively charged nucleus of an atom. Soon the brilliant Italian physicist Enrico Fermi was bombarding all sorts of atoms, including uranium, with neutrons. By 1934 Madame Curie's daughter, Irene, and her son-in-law, Jean Frederick Joliot, had discovered artificial radioactivity by which such common materials as salt and aluminum can be made to behave like radium. Still later Dr. Ernest Lawrence, an American, invented the cyclotron by which atoms can be broken by being bombarded with extremely rapidly-moving particles.

In all of the above processes of artificially decomposing atoms the quantity of energy obtained from the fissions was less than that which had to be used to bring them about. It remained for Hahn and Strassman to bombard uranium with slow-moving neutrons and obtain a new effect. Dr. Lise Meitner, an Austrian physicist, and Dr. O. R. Frisch correctly interpreted this effect to the fission of uranium-235.

This bring us to the subject of isotopes, which are different kinds of atoms of the same element having different weights. Most uranium atoms weigh 238 on the atomic weight scale. About one in 140 weighs 235 and one in 17,000 weighs 234. Ever since 1939 it has been evident to chemists and physicists that all that is needed to obtain atomic energy is to separate U-235 from the other two isotopes.

Incidentally, the story that Lise Meitner is Jewish is incorrect. John Meitner, her nephew, is a member of the Department of Chemistry at Purdue and has given us some interesting facts about her life. Lise is one of a family of seven all of whom earned Doctors' degrees. Her father decided that she was too stupid to go to high school so she studied by herself at home, passed the senior examinations, and received her diploma. She left home for Berlin where she worked her way through college and became head of the Physics Department of the Kaiser Wilhelm Institut. She left this position in 1939 of her own free will; she had never taken out German citizenship papers. She, as well as the rest of her family, is anti-Nazi and she sensed the importance of the discovery and what would happen to the world with the secret in the hands of Hitler.

The results were checked by several experimenters both in Europe and the United States and the grim race was on. Whatever nation was first able to separate U-235 could rule the world if it wanted to do so.

The first separation of isotopes on a microscopic scale was accomplished about twenty-five years ago by Aston in England. The process consists in making the atoms one by one go around a curve at high speed in a high vacuum. Just as a heavy guard on a football team can't turn and dodge as quickly as a light halfback, the heavy atoms don't change direction as readily as the lighter ones. One of the processes for separating U-235 from the other isotopes is based on an enlargement of this mass spectrograph, as it is called.

The first separation of isotopes in quantity was performed by

Prof. H. C. Urey of Columbia University who received a Nobel prize for making heavy water. This involved separating H^1 from H^2. Urey and his group were very quickly drawn in to the problem of isolating U-235 and worked on a diffusion process which took advantage of the fact that a light isotope will move a little faster than a heavy one and, therefore, has a slightly greater chance of finding a hole in a filter and working its way through it. By repeating this process hundreds of times the desirable isotope can be separated.

Another approach to the problem of release of atomic energy consists in producing from uranium 238 new chemical elements such as neptunium which spontaneously changes into plutonium. Plutonium has a doubly appropriate name for Pluto is a planet beyond Uranus in the solar system and Pluto was also the god of the underworld in Roman mythology.

At the University of Chicago a complicated device was built for producing plutonium from U-238 and then separating the two. This separation was relatively easy because they are two different chemical elements rather than isotopes of a single one.

As all three of these processes—(1) shooting uranium atoms around a curve, (2) separating uranium atoms by diffusion through a filter, and (3) making plutonium—showed promise, large plants were constructed to put them into operation. The plutonium plant was at Hanford, Washington, the other two at Oak Ridge, Tennessee. There was no time for the usual less expensive method of building pilot plants since each day cut off of the war would save about 200 million dollars. Some of the plants were obsolete before they were finished, because of the rapidity with which new knowledge was gained. A hundred and twenty-five thousand men were used and two billion dollars were spent on the project but it paid for itself many times over even without considering the lives saved. The secrecy maintained was remarkable. When the atomic bomb exploded there were people in our Chemistry Building who did not know that we had been working on it.

The rapid ending of the war caused by the explosions at Hiroshima and Nagasaki is familiar to us all. Many important questions are still being discussed; among these are: was the bombing morally justified. It is estimated by Churchill that by the use of this new weapon a quarter of a million British lives and a million American lives were saved. But the records of the Pacific war show that Japanese casualties exceeded ours by a

very large ratio; it may therefore be reasonable to assume that something like 10,000,000 Japanese lives were saved. Whether this is a good thing is perhaps debatable but there is no doubt that the net effect of the bomb was to save many millions of lives.

Can we outlaw its use in war? Military history shows no example of the successful outlawry of any really effective weapon. War is a grim business of killing or being killed and that being the case, you can hardly expect a nation to fail to use a weapon which gives it an advantage. Much has been said about the failure of the Nazis to use poison gas in World War II. Anyone familiar with the horrors of Buchenwald prison camp can hardly attribute this to humanitarianism; probably the fact that the U. S. has much the largest chemical industry in the world was the important reason.

Can we keep the secret? Yes, for a few years, but not in the long run. In the very near future any nation which wants to expend the necessary research effort can have atomic bombs.

Will it be harnessed for constructive peace-time use? The whole history of science shows that every new form of energy has been successfully harnessed. It is only a matter of time.

What will it mean for the human race? That is for mankind to decide. If we wish, we may have a new era of civilization which will set us on the road leading to the abolition of poverty and infectious diseases. Or we may have wars which will make World War II look like a Sunday School picnic.

Never before was more effectively illustrated the fact that science is power; power to do good or evil. Increasing the power of mankind is one-half of human progress; the other half consists in the art of learning to what purposes we should use the increased power and persuading people to want to use it for good. The physical scientist, the social scientist, and the clergy together should face the problems of atomic power as the greatest opportunity ever offered a civilization. There is no use in deploring the inexorable march of scientific progress; the future belongs to the nations which most eagerly accept and exploit it.

An important lesson to be learned from this development is that in science the brotherhood of man is already functioning. British, French, German Jew, Austrian, Italian, Pole, and Americans all contributed essential steps in the solution to this problem. Let no one say that we can't cooperate for our mutual benefit. We have been doing it for decades.

The other important lesson, it seems to me, is the significance of research with no immediate practical end in view. If Becquerel or Einstein or Meitner had been asked what he or she intended to accomplish by their researches, no good answer could have been given. The universe is too vast and complicated to see very far ahead in scientific research. Let us have confidence in the skilled researcher who has a highly developed instinct for what may ultimately prove to be important. Very often he is wrong but his research director is wrong still more often and a non-scientist will be wrong almost all of the time if he tries to select research problems for the scientist. Give the scientists a chance and they gradually will solve almost any problem in which they are interested.

Since August 5th the capacity of the great American public to indulge in wishful thinking has exceeded even the most pessmistic prophesies. We read newspaper accounts of counter-measures in spite of the plain scientific fact that, as Langmuir has expressed it, "the only defense against the atomic bomb is to be somewhere else when it explodes."

The implication of the atomic bomb is as clear as crystal. Either a strong international organization must be set up, capable of controlling the production of plutonium, uranium 235 and any other atomic explosives still to be discovered, or World War III is just a decade or two away. We either must choose world government or disperse our cities and join the ants in a subterranean existence. We can not leave this situation to the admirals who in 1920 scoffed at air-power or the same kind of tradition-bound political thinking which swerved toward isolation after World War I. It is up to those of us with the scientific and educational background to understand what is happening to arouse America. There is terribly little time left in which to act.

TO ERR IS HUMAN

Even the greatest money makers have been known to pass up good bets. Charles M. Schwab refused to back the Wright brothers because he thought aviation was a crazy idea. Western Union when offered Bell's telephone patents for $100,000, turned them down because its directors felt that the corporation's province lay in long distance communication. And Cornelius Vanderbilt rejected Westinghouse's airbrake on the ground that he had no time to waste on such fool ideas as stopping trains with wind.—*Commentator.*

HISTORY OF ALGEBRA

WALTER H. CARNAHAN
Purdue University, Lafayette, Indiana

The articles of this series are from scripts of broadcasts over radio station WBAA. This series is a part of the Purdue University *School of the Air*. There is one broadcast each week on some subject of mathematics. The first series had the general title *Mathematics Is Where You Find It* and ran for thirteen weeks. A second series of thirteen broadcasts has the title *Mathematical History and the Men Who Made It*. The articles as here given are in the exact words in which they were broadcast. They have been timed to be read in thirteen and a half to fourteen and a half minutes a the rate found most effective for understanding by the radio audience. Rebroadcasting of these talks in the original form or with adaptations is permitted. Write to the author for specific permission for their use.

1

Elementary algebra is much like arithmetic in several ways. They both solve problems that have something to do with numbers. They both make use of signs and symbols of different kinds. The operations to be done in the two subjects are often about the same. Probably you have heard it said that algebra is generalized arithmetic, and to a certain extent that is true, and yet there are many differences between the two subjects. For example in arithmetic, you can generally combine all numbers as you go and get one number which you can label and tell just what it stands for. In algebra you cannot do this. In arithmetic if you understand addition and subtraction of numbers and their short cuts which we call multiplication and division, you can solve most problems that you are likely to find in the affairs of life. In algebra, on the other hand, you need to understand many special operations, definitions, conventions and symbols.

Much of the history of algebra tells about the steps through which men have set up the special operations, symbols and processes that make algebra different from arithmetic and make it possible to do by algebra many things which cannot be done by arithmetic.

No doubt you who take algebra have found that word problems are some of the hardest in your book. Perhaps you have sometime said about one of these, "If someone would tell me the equation, I could solve it." Now, I am sure you would not want to be spoon fed to that extent, but when you say that, you are paying tribute to the men who through many years and

centuries have worked out the symbols and rules of operation that make solving of algebra equations so easy. I shall tell you some of the steps in this long story.

Two thousand five hundred years ago, not only were the problems of algebra nearly all word problems, but every step in the solutions was a word statement. In other words there were no x's or plus signs or exponents. Men talked or wrote in word statements every step in solving problems. We call this *rhetorical algebra*. It was *words, words, words*. In that day algebra was really hard. After one year in high school algebra today, you can solve problems that would have stumped the first scholars of that day. In order to make algebra less repulsive, the mathematicians of olden times put their problems in very fanciful settings. Just listen to this problem: "A mule and a donkey were walking along laden with corn. Said the mule to the donkey, 'If you should give me one measure, I would carry twice as much as you. If I should give you one, we would both carry equal burdens.' Tell me their burdens, O most learned master of geometry." A thousand years later, they were still putting their problems in poetry and fanciful language, not only for school pupils but for entertainment at parties. Here is one of the later problems: "The square root of half the number of bees in a swarm has flown out upon a jasmine bush, and 8/9 of the whole swarm has remained behind. One female bee flies about a male that is buzzing within a lotus flower into which he was allured in the night by its sweet odor, but is now imprisoned within it. Tell me the number of bees."

Of course the ancients had special methods of their own for solving such problems, but since they had to do everything with words, using no symbols and equation rules which we know, the wonder is that they could solve as many problems as they did. They grew tired of the long, wordy solutions just as you would, and gradually there appeared problems that they could solve only with the longest, hardest labor. Then they began to abbreviate the words, sometimes using only the first letter of the word. This reduced the amount of writing and made the steps in the work much easier. We call this *syncopated algebra*.

About 3700 years ago an Egyptian by the name of Ahmes wrote a mathematics book called *Directions for Obtaining the Knowledge of All Dark Things*. A good big title, wasn't it? In this very old book, a copy of which is still in existence, there are problems that sound just like simple word problems out of your

algebra. Here is one: "A number added to 1/7 of itself gives 19." But Ahmes and the Egyptians did not solve such problems by algebra, so far as we know. As pupils sometimes say today, "they just figured it out." In other words they tried out different numbers until they found one that would do.

And that is as far as algebra was developed before the Greeks entered their great age of cultural development about 600 B.C., 2500 years ago. The Greeks took to mathematics like ducks take to water, but they liked geometry much better than algebra and for a long time they tried to tie algebra onto their geometry as you tie a tail onto a kite. When they had an algebraic quantity, they usually tried to draw a line, or a square, or a rectangle, or combinations of these figures to represent the algebraic quantities and their relations. This wasn't such a bad idea, and even today we find this very helpful sometimes. However, there were some weaknesses in this. For example, the Greeks thought it absurd to think of a minus line or a minus area, or anything at all less than nothing, and so they simply refused to consider what we call negative numbers. Thales, Euclid, Pythagoras and other great mathematicians among the Greeks solved some problems such as you find toward the end of your high school algebra course, but you would scarcely recognize their solutions as algebra. They drew geometric figures and based their solutions on these, and their statements were written out as word statements with very few abbreviations or symbols. This is what we have called rhetorical algebra, but the Greeks made it geometric rhetorical.

There was one Greek who wrote algebra much as we would do today. His name was Diophantus and he lived about 250 years after Christ, that is 8 or 9 hundred years after the Greeks first turned their minds to science. Diophantus used symbols and letters for numbers along with the words and abbreviations, and he did not think it necessary to draw geometry figures to help in the solution of all problems. He was far ahead of any one who studied algebra before him and even for 600 years after his time. In fact, he is often called the father of the science of algebra. A certain type of equation is called a Diophantine equation to this day. His algebra is still read by scholars. It was the very first algebra book even written, and the only one worthy of the name for 600 years after his death.

This does not mean that no one was studying algebra and learning new and better ways of doing it, but only that the

discoveries and improvements were not brought together and written down in books of any influence or value.

The man who contributed the second algebra book that brought together the accumulated knowledge of the subject was an Arab whose name was Khowarizmi (that is K-H-O-W-A-R-I-Z-M-I). He not only wrote a book on the subject, but he gave the subject its name, algebra. The title of his book was "Transposing and Combining" which in the Arabic language was *al-jebr w'almuqabala*. In speaking or writing about the book, people soon dropped the second big word (perhaps because they found it hard to say) and called it Al-jebr or algebra. Soon the word algebra came to mean not only Khowarizmi's book but the whole subject about which it was written. Perhaps you wonder what they called the subject before it was called algebra. Well, it had no name. What we call algebra was only a small part of other books or subjects and had no separate designation. Diophantus, for example, wrote his algebra under the title *arithmetic*.

What had been learned about algebra between the time when Diaphantus summed up the knowledge of the subject 250 A.D. and the time when Khowarizmi wrote *al-jebr w'almuqabala* about 600 years later? For one thing, men had learned that negative numbers were just as good as positive ones and they used the two kinds in exactly the same way. In the second place, they had learned to accept and use numbers, such as square root of 2, that could not be exactly expressed as integers or mixed numbers. Then they had found new methods of solving equations. Altogether scholars by the time of Khowarizmi had learned to multiply, divide, add, subtract and solve first and second degree equations about as you now do in freshman algebra. Their ways of doing these things were not like ours and they did not use many of the symbols and ways of writing that we use, but they knew enough to work the problems we work. Besides, they knew many special facts that do not appear in your books. They had applied problems at that time but they were not applied to automobiles and air planes, of course; their applications were to astronomy, geometry, and puzzle problems and perhaps to a few other subjects.

After Khowarizmi, there were many other Arabs who studied and taught algebra but they made few new discoveries. They were content to know what Khowarizmi had written in his great book. About 200 years after Khowarizmi lived the Arab

poet Omar Khayyam whose verses you can still buy at the corner drug store. He was a mathematician as well as poet and made one very important contribution to algebra. Before his time, writers and teachers had treated each problem or each small group of problems as distinct from others and had no system that would solve a considerable number of problems. Omar Khayyam worked out a system that would take care of many problems and thus made it possible for one person to teach another.

As you know, the Arabs under the religious leader Mohammed conquered a large part of the world. Wherever they went, their scholars took their mathematics and taught it to other people. 300 years before Columbus came to America, an Italian by the name of Leonardo learned all the Arabs knew about algebra, added some ideas of his own and wrote in Latin a book called *Liber Abaci*. Besides being a good book it was written in a language understood by all learned Christians, and so it brought to the church schools the science of algebra. For hundreds of years, Christian scholars used *Liber Abaci* as the source of knowledge about algebra and copied its problems over and over.

After Leonardo wrote his great book, progress in the development of algebra was very slow for 300 years. Colleges allowed students to enter and graduate without mathematics of any kind, and only a few scholars took any interest in studying and improving algebra. About the time Columbus came to America, however, there was a great new interest in all learning and new ideas all over Europe, both in and out of the schools. All of a sudden, many men turned their minds to learning and making improvements in algebra. The old methods of using words and abbreviations in solving problems, or the clumsy method of using geometric figures to interpret algebraic relations were too slow and difficult. Men began to suggest new and better symbols and more direct ways of working. As a result of this new interest and those improved symbols, discoveries in algebra were made so fast that it was hard for the best scholars to keep up. Within 100 years after America was discovered, that is to say about 350 years ago, elementary algebra was almost as it is today. Many discoveries in advanced or university algebra remained to be made but that does not interest us at this time.

Let us now recall some of the detailed changes that have been made in algebra over the centuries. First, let us review the

history of what we now call the unknown, or the variable, or the literal number. You could hardly think of algebra without x's and y's and values to be found by solving equations. 3700 years ago the Egyptians called the unknown "a heap" and all they meant was an unknown number. 2000 years later, Diophantus used the initial letters of various words according to a very good system of his own. In English, he would have used N for number as we often do, and for the square of a number he would have used S, and so on. 600 years after Diophantus, Khorwaizmi the Arab followed much the same system as Diophantus, using what in English would be R for root meaning the unknown number and S for square if he wanted to indicate the second power of the unknown. Some Hindus had the interesting custom of calling unknown numbers with the names of colors, red, white, black and blue, and so on. During the time of the new learning in algebra in Europe, the unknown was often called *res*, which meant "the thing," or *coss*. Some writers tried using special pictures or symbols but this idea did not catch on.

SINCE 1937, RUSSIA'S COLLEGES HAVE TRAINED 3,900 FOR DOCTOR'S DEGREE IN SCIENCE; 20,000 HAVE BEEN GIVEN MASTER'S DEGREE

In Soviet Russia, 3,900 scientists were graduated from the colleges with the degree of doctor in the years 1937 to 1944; about 20,000 received a master's degree, according to Joseph Agroskin, vice-chairman of the Committee on Higher Education in Moscow.

The Soviet Government has been paying particular attention to the matter of training scientists, Vice-Chairman Agroskin said, because of the pressing need for teachers of technical subjects in the colleges due to a greatly increased student body.

In 1929, there were only 26,000 engineers with diplomas in all the heavy industries of Russia. But in the last six years, about 80,000 engineers were graduated.

In pre-revolutionary Russia, Vice-Chairman Agroskin said, higher education was for the privileged few of the upper strata. In 1914, Russia had only 91 colleges with 112,000 students. The Soviet Government placed the entire system of higher education on new principles. Nationality and class distinctions were abolished. Education was free. All nationalities were permitted to teach in their own languages in colleges on the territory of their own national republics. Both universities and institutes were opened to all working people.

As a result, there are now 772 colleges with 562,000 students. Of these 132 are industrial institutes, 18 transport institutes, 87 agricultural institutes, 68 medical institutes, 115 pedagogical colleges and 29 universities.

In 1925, Vice-Chairman Agroskin reported, there were only 17,900 professors and lecturers in all Russia's colleges. Now there are 40,000.

THE ELEMENTARY SCHOOL SCIENCE LIBRARY FOR 1944–1945

PAUL E. KAMBLY
University Experimental School, Iowa City, Iowa.

This second list of reference books for elementary school science includes the books published after the preparation of last year's list.[1] The few exceptions are books that should have been included in the 1944 list.

The grade levels indicated are the lowest recommended by the compiler on the basis of an examination of each book. The annotations are included to help the elementary school teacher determine the possible usefulness of the references in supplementing her science program. The prices are listed and are subject to change. The subject matter divisions under which the books are listed are for convenience only.

Publishers have been very cooperative in suggesting books for inclusion on this list and providing examination copies. Many publishers of children's books had no books to offer for this list but expect to have as soon as materials and help are available. They all indicated a desire to make suggestions in future years.

REFERENCE BOOKS FOR ELEMENTARY SCHOOL SCIENCE

Animals

(See also book on birds)

	Gr.	Price
Animals That Live Together. By G. O. Blough. 36 pp. '45. Row*	1	.32
Bees, beavers, ants and termites. The activities and life histories of these animals are clearly presented and well illustrated.		
Animals and Their Young. By G. O. Blough. 36 pp. '45. Row	1	.32
Painted turtle, grasshopper, frog, monarch butterfly, killdeer, robin, bob-white, cat, pigeon, rabbit, lamb and fawn. Elementary facts that are well illustrated.		
Son of the Walrus King. by Harold McCracken. 129 pp. '44. Lippincott	4	2.00
The growth, training and adventures of a young walrus. A good picture of Arctic animal life.		
Two Children and Their Jungle Zoo. By Rose Brown. 220 pp. '44. Lippincott	6	2.00

[1] Kambly, Paul E.: "The Elementary School Science Library," SCHOOL SCIENCE AND MATHEMATICS, 44: 756–767. November, 1944.

* Publishers and their addresses are listed at the end of this section.

Tatu and Joa explore the Amazon jungle and collect a zoo of jungle pets. The Portuguese words increase the reading difficulty.

Astronomy

Picture Book of Astronomy. By J. S. Meyer. 36 pp. '45. Lothrop........ 1 1.75
The sun, moon, planets and stars. For the teacher to read to primary grade children.

Biography

Raymond L. Ditmars. By L. N. Wood. 272 pp. '44. Messner. 5 2.50
The story of an American boy who turned a hobby into a profession. Contains a great deal of information about snakes.

Birds

Birds in the Big Woods. By G. O. Blough. 36 pp. '45. Row... 1 .32
Woodpecker, nuthatch, kingfisher, heron, crow, oriole, hummingbird, cowbird, owl, warbler, cardinal, bluejay and robin. Emphasis on the food habits of birds but includes information on nests, migration and economic value.

Conservation

Saving Our Wild Life. By B. M. Parker. 36 pp. '44. Row.... 4 .32
The need for conservation of plants and animals and what we can do to help.

Pandora's Box—The Story of Conservation. By M. E. Baer. 292 pp. '39. Farrar........ 5 2.00
A readable book about wildlife, forests and soil.

Use Without Waste. By M. R. Hafstad and G. E. Hafstad. 168 pp. '44. Webster........ 5 .80
Excellent information on conservation of forests, soil, wildlife and minerals. The teaching suggestions may be of value to some teachers.

Your Forests. By Bensley Bruere. 159 pp. '45. Lippincott.. 6 2.50
The story of American forests: what they are, where they are, how they are cared for and developed by the U. S. Forest Service. How forests are used for our own profit and enjoyment.

Electricity and Magnetism

Electricity. By B. M. Parker. 36 pp. '44. Row........ 4 .32
Basic information about dry cells, current electricity and how electricity helps man.

General Science

How the Sun Helps Us. By G. O. Blough and I. B. DePencier. 36 pp. '45. Row........ 1 .32
The nature of the sun, heat from the sun and photosynthesis.

Useful Plants and Animals. By G. O. Blough. 36 pp. '45. Row........ 1 .32
Horses, dogs, mules, burros, camels, meat animals, silk-

worms, sheep, fur-bearers, birds, rubber trees, cotton, linen and food plants. Well illustrated.

All Around Us. By W. L. Beauchamp, Gertrude Crampton and W. S. Gray. 80 pp. '44. Scott.................. 2 .96
Color pictures of animals; tools; sun wind and weather; and plants. Intended to promote further exploration in science.

What Things are Made Of. By B. M. Parker. 36 pp. '44. Row 4 .32
An elementary discussion of elements, compounds and mixtures. Also includes an elementary introduction to chemical changes.

The Story of War Weapons. By Marshall McClintock. 173 pp. '45. Lippincott.............................. 5 2.50
From small arms to giant weapons. Includes a chapter on the pen and radio.

Plants

Plant Factories. By B. M. Parker and O. D. Frank, 36 pp. '44. Row.. 4 .32
Photosynthesis and the many products that are synthetized by green plants.

Science and Industry

Oil and Gas. By Pennsylvania Writers' Project. 48 pp. '44. Whitman.................................... 3 .50
Describes man's early knowledge of petroleum, its discovery in the United States, the refining process and its use in the United States.

The Story of Coal. By Pennsylvania Writers' Project. 47 pp. '44. Whitman................................ 3 .50
The formation of coal, mining methods and the by-products of coal.

The Story of Iron and Steel. By Pennsylvania Writers' Project. 45 pp. '44. Whitman......................... 3 .50
The making of iron and steel in simple non-technical language.

Copper: The Red Metal. By J. M. Metcalfe. 104 pp. '44. Viking....................................... 6 2.00
An accurate story of copper from the time it leaves the ground until it emerges from the smelter. Many allusions to historical development of copper mining.

Transportation

Pogo's Train Ride. By J. Norling and Ernest Norling. 41 pp. '44. Holt.................................... 2 1.25
A story of freight trains. John and his dog Pogo visit a roundhouse, where they learn how a locomotive works. Then they make an overnight trip on a freight train.

Airplanes and How They Fly. By Marshall McClintock. 94 pp. '43. Lippincott.......................... 4 2.00
Why and how an airplane flies with many drawings to illustrate the text.

How Planes Get There. By Aviation Research Associates. 64 pp. '44. Harper........................... 6 1.00
A clear, simple explanation of aerial navigation with several illustrations.

Planes in Action. By Aviation Research Associates. 64 pp. '44. Harper	6	1.00
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ELASTICITY OF ELEMENTARY FUNCTIONS
Part 1, Definition and Properties

J. S. GEORGES
Chicago City Junior College, Wright Branch

From times immemorial the development of mathematics has been along two distinct lines. On the one hand, mathematical thought has been extended along conceptual and abstract lines, often centuries elapsing before such mathematical systems have been found useful instrumentalities in the solution of practical problems. On the other hand, mathematics has progressed through the invention or discovery of new mathematical concepts or processes for the specific purpose of solving practical problems. However, the abstract mathematics of one day may become, as it has in many instances in the past centuries, the very essence of practicality of another day. Similarly, mathematics which may be placed in the catagory of the practical today may be generalized into an abstract mathematical system tomorrow.

The development of the calculus furnishes an excellent illustration of this idea. Following the outstanding achievements of such pioneers of science as Copernicus, Kepler, Gallileo, and Brahe, the problem of gravitational attraction was solved completely by Newton because he was able to use the new method of infinitesimal analysis, or the calculus. In the hands of Newton this new method of analysis was devised to solve a specific problem. To that extent it was practical mathematics. Yet we know today that this method of analysis had been invented by the greatest of ancient mathematicians, Archimedes, centuries before. We may surmise that he too invented the calculus and used it in the solution of such practical problems as determining areas and volumes. Today, however, still retaining the practical applications of the calculus, mathematicians have made of it the very essence of abstraction in general analysis, extending the domains of thought to staggering dimensions.

At this point we may make the following conjecture. Suppose that Archimedes in his day had interested himself in some socio-economic problem instead of physical problems, would he have, perhaps, invented a mathematical system unlike that known to the ancients, and perhaps unlike the mathematics we

know today? Or, suppose that in the time of Newton he and other mathematicians and philosophers had likewise become interested in socio-economic phenomena rather than in cosmological phenomena, would we have a different type of mathematical analysis today? Or, suppose even today that the best mathematical researches would be devoted to the formulation and solution of socio-economic problems, would we have a different world today? Perhaps a world free of turmoil and confusion, an ordered world, a simplified world order in which the dreams of the past generations as well as the hopes of our generation would be realized.

That the mathematical thought has in the past sought practical applications in the physical world rather than in the economical world may be due to the nature of the two worlds. The question can not be answered by merely referring to the complex nature of the economical phenomena. For, the physical world is just as complex. If we infer that socio-economic phenomena involve too many variable factors, then we can refer to such a complex phenomenon as the mutual gravitational attraction of many bodies. Every student of celestial mechanics knows the complexity of the problem of three bodies, let alone that of four or more bodies. Yet we can, by means of mathematical analysis available to us, predict the occurrence of an eclipse years in advance. On the other hand, with all the mathematics at our disposal, we are unable to make any reliable predictions in the socio-economic world. Perhaps the solution of our problem lies in the invention of new mathematical systems which will enable man to analyze and solve problems in the socio-economic world, as readily as he does in the physical world. Until that is achieved, however, we should concern ourselves with the complete utilization of our present mathematical systems.

While the actual solution of this problem will have to be postponed until such a time when we have capable research mathematicians who have an adequate background in sociology and economics, and capable economists and sociologists who are equally capable mathematicians, we can do our share in preparing for that day by emphasizing socio-economic problems in mathematics classes from the elementary school through the high school to the college and university. We can, in a limited way, illustrate mathematical concepts and processes in terms of socio-economic problems also, and not draw on examples from

physical sciences alone. We can as teachers of mathematics hasten that day by demanding such instructional materials in our textbooks and courses of study.

The theme of this sequence of articles is to present the concept of the elasticity of functions, as one of those mathematical concepts which has been found to have great importance in economics, and which, if presented properly, can yield rich interpretations in mathematics as well as other sciences. This concept, as potent, perhaps even more so, than the associated concept of the rate of change of a function, has been entirely neglected in mathematics courses. We shall endeavor to point out its applications not only in the field of economics, but also in that of mathematics and other sciences.

Let us consider a variable x changing in value from x to $x+\Delta x$. The amount of change is Δx, the increment of x, and the amount of proportional change is $\Delta x/x$. Now let us consider any function of x, say $f(x)$, which changes in functional value, due to the change in the value of x, from $f(x)$ to $f(x+\Delta x)$. The amount of change of $f(x)$ is $f(x+\Delta x)-f(x)$, and the amount of proportional change is $[f(x+\Delta x)-f(x)]/f(x)$. Now let us represent the average rate of proportional change of $f(x)$ per unit of proportional change of x. It is

$$\epsilon_x(y)=\frac{f(x+\Delta x)-f(x)}{f(x)}\bigg/\frac{\Delta x}{x}=\frac{x[f(x+\Delta x)-f(x)]}{f(x)\Delta x}=\frac{x\Delta y}{y\Delta x} \qquad (1)$$

where y represents the function $f(x)$, and $\epsilon_x(y)$, the average rate of proportional change. We call $\epsilon_x(y)$ the ***average elasticity*** of y with respect to x.

Example 1. Let $y=ax$. The average rate of change of y with respect to x is $\Delta y/\Delta x=a$. The average elasticity, or the average proportional rate of change, of y with respect to x is 1. Thus, while the average rate of change of the circumference of a circle with respect to the radius is $\Delta c/\Delta r=2\pi$, the elasticity of the circumference with respect to the radius is 1, which means that proportionally the circumference is changing with the same rate as the radius. Also, while the average rate of change of the circumference with respect to the diameter is $\Delta c/\Delta d=\pi$, again the elasticity of the circumference with respect to the diameter is 1.

Example 2. Let $y=ax^2$. The average rate of change of y with respect to x is $\Delta y/\Delta x=2ax+a\Delta x$. The average elasticity of y with respect to x is $\epsilon_x(y)=2+\Delta x/x$. Thus, the average rate of

change of the area of a circle with respect to the radius is $\Delta A/\Delta r = 2\pi r + \pi\Delta r$. Which means that the average rate tends toward $2\pi r$ as Δr tends toward zero. On the other hand, the average elasticity $\epsilon_r(A) = 2 + \Delta r/r$ tends toward the constant value 2 as Δr tends toward zero. This distinction becomes more significant as we consider instantaneous rate and elasticity.

Let the differential $f'(x)$ of the function $f(x)$ exist. Then

$$E_x(y) = \underset{\Delta x \to 0}{\text{Limit}} \frac{x[f(x+\Delta x) - f(x)]}{f(x)\Delta x} = \frac{xf'(x)}{f(x)} = \frac{xdy}{ydx} \tag{2}$$

where $E_x(y)$ is the elasticity of the function $y = f(x)$ with respect to x. It is to be noted that $E_x(y)$ is the double ratio $(dy/y)/(dx/x)$, as well as the double ratio $(dy/dx)/(y/x)$. The latter form exhibits the fact that the elasticity of y is the rate of proportional change of y in terms or proportional change of x.

Now since $d(\log y)/dy = 1/y$, and $d(\log x)/dx = 1/x$, it follows that

$$E_x(y) = \frac{d(\log y)}{d(\log x)} \cdot \tag{3}$$

Interpreting the elasticity of $y = f(x)$ as the ratio of the differential of log y to the differential of log x, it is obvious that the elasticity of a function is the slope of its curve when sketched on logarithmic coordinates paper.

Example 3. Let $y = ax^n$, then $E_x(y) = n$. That is, the elasticity of the power function ax^n is constant and equals the exponent n. Thus, the elasticity of the circumference of a great circle on a sphere with respect to the radius is 1, the elasticity of the area of the sphere with respect to the radius is 2, and the elasticity of the volume of the sphere with respect to the radius is 3. The simplicity of these relations is apparent when they are compared with the respective rates of change.

The characteristic difference between the rate of change and the elasticity of a function lies in the fact that in determining the rate of change at any instant the functional value at that instant is not taken into consideration, whereas in determining the elasticity of a function at any instant the functional value at that instant must be considered.

Example 4. For both functions $y = ax$ and $y = ax + b$ the rate of change is $dy/dx = a$ for any given value of x. On the other hand, the elasticity of $y = ax$ is $E_x(y) = 1$, while the elasticity of

$y=ax+b$ is $E_x(y)=1-b/(ax+b)$. In Figure 1 $y'=1/2$ is the derived curve for the functions $y=1/2x$ and $y=1/2x+1$. In Figure 2 the elasticity curve $E_x(1/2x)=1$ is a horizontal asymptote for the elasticity curve $E_x(1/2x+1)=1-1/(1/2x+1)$, and the latter curve has a vertical asymptote for $x=-2$. Furthermore, the elasticity curve $E_x(1/2x)$ shows that for every value of x the proportional increase in the value of x produces an equal

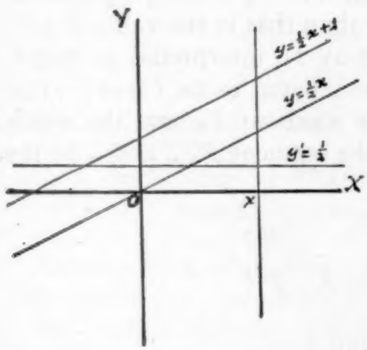

FIG. 1

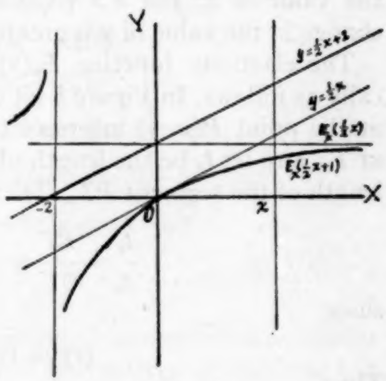

FIG. 2

proportional increase in the value of y. On the other hand, the elasticity curve $E_x(1/2x+1)$ shows that for all values of x greater than -2 a proportional increase in the value of x produces a smaller proportional increase in the value of y, and for all values of x less than -2 a proportional increase in the value of x produces a greater proportional increase in the value of y.

Example 5. For both functions $y=ax^2$ and $y=ax^2+c$ the de-

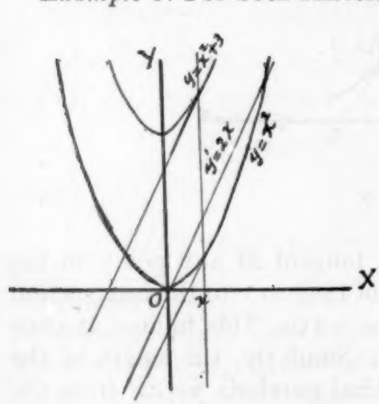

FIG. 3

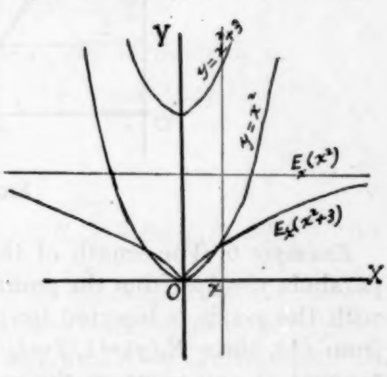

FIG. 4

rived function is $y'=2ax$. Figure 3 shows the derived function $y'=2x$ for the curves $y=x^2$ and $y=x^2+3$. In Figure 4 the elasticity curve $E_x(x^2)=2$ is the horizontal asymptote of the elasticity curve $E_x(x^2+3)=2-6/(x^2+3)$. Since the elasticity curve of Figure 4 is a function of x, for $x=\pm\sqrt{3}$ the numerical value of the elasticity is 1. Thus for $-\sqrt{3}<x<+\sqrt{3}$ the proportional change in the value of y is less than the proportional change in the value of x. For $x>+\sqrt{3}$ and $x<-\sqrt{3}$ the proportional change in the value of y is greater than that in the value of x.

The elasticity function $E_x(y)$ may be interpreted geometrically as follows. In Figure 5 let the tangent to the curve $y=f(x)$ at the point $P(x, y)$ intersect the x-axis at T_x, and the y-axis at T_y, and let t_x be the length of the segment PT_x, and t_y be the length of the segment PT_y. Then

$$\frac{t_y}{t_x}=\frac{RP}{QT_x}=\frac{x}{ydx/dy}=\frac{xdy}{ydx},$$

since

$$QT_x=PQ(dx/dy).$$

Thus,

$$E_x(y)=t_y/t_x. \tag{4}$$

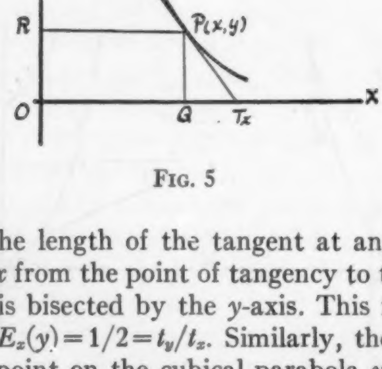

FIG. 5

Example 6. The length of the tangent at any point on the parabola $y^2=4px$ from the point of tangency to the intersection with the x-axis is bisected by the y-axis. This follows at once from (4), since $E_x(y)=1/2=t_y/t_x$. Similarly, the length of the tangent at any point on the cubical parabola $y=ax^3$ from the point of tangency to the intersection with the y-axis is 3 times

the length of the tangent from the point of tangency to the intersection with the x-axis. For in this case $E_x(y)=3=t_y/t_x$.

Since $E_x(y)$ involves dy/dx, expressions for $E_x(u\pm v)$, $E_x(uv)$, and $E_x(u/v)$, where u and v are functions of x, can be readily determined. Thus

$$E_x(u\pm v)=\frac{uE_x(u)\pm vE_x(v)}{u\pm v} \tag{5}$$

$$E_x(uv)=E_x(u)+E_x(v) \tag{6}$$

$$E_x(u/v)=E_x(u)-E_x(v). \tag{7}$$

The derivation of (6) will illustrate the process.

$$E_x(uv)=x/uv\cdot d(uv)/dx=x/uv(vdu/dx+udv/dx)$$
$$=xdu/udx+xdv/vdx=E_x(u(+E_x(v).$$

Example 7. $E_x(\sin x/\cos x)=E_x(\sin x)-E_x(\cos x)=x(\cot x+\tan x)=x\sec^2 x/\tan x=E_x(\tan x)$.

The partial elasticity of a function of two or more variables is defined in terms of the partial derivatives as follows. Let $u=f(x, y, z)$, then

$$E_x(u)=x/u\cdot \partial u/\partial x;\quad E_y(u)=y/u\cdot \partial u/\partial y;\quad E_z(u)=z/u\cdot \partial u/\partial z. \tag{8}$$

However, the use of parametric equations brings out the significance of the elasticity more clearly. Let

$$x=f_1(t),\quad y=f_2(t),\quad z=f_3(t),\quad \text{and}\quad U=F(x, y, z),$$

then

$$dU=\partial F/\partial x\cdot dx+\partial F/\partial y\cdot dy+\partial F/\partial z\cdot dz,$$
$$dU/dt=\partial F/\partial x\cdot dx/dt+\partial F/\partial y\cdot dy/dt+\partial F/\partial z\cdot dz/dt$$
$$t/U\cdot dU/dt=(t/x\cdot dx/dt)(x/U\cdot \partial F/\partial x)+(t/y\cdot dy/dt)(y/U\cdot \partial F/\partial y)$$
$$+(t/z\cdot dz/dt)(z/U\cdot \partial F/\partial z).$$

Thus,

$$E_t(U)=E_x(U)E_t(x)+E_y(U)E_t(y)+E_z(U)E_t(z). \tag{9}$$

Example 8. Let $L=\sqrt{x^2+y^2+z^2}$ be the diagonal of a rectangular parallelopiped, $A=2(xy+xz+yz)$ its surface area, and $V=xyz$ its volume. Let $x=at$, $y=bt$, and $z=ct$. Then, $E_t(x)=1$, $E_t(y)=1$, and $E_t(z)=1$. Since, $E_x(L)=x^2/L^2$, $E_y(L)=y^2/L^2$, and $E_z(L)=z^2/L^2$, it follows by (9) that $E_t(L)=(x^2+y^2+z^2)/L^2=1$.

Similarly, since $E_x(A) = 2(xy + xz)/A$, $E_y(A) = 2(xy + yz)/A$, and $E_z(A) = 2(xz + yz)/A$, it follows by (9) that $E_t(A) = 4(xy+xz+yz)/A = 2$. Finally, since $E_x(V)=1$, $E_y(V)=1$, and $E_z(V)=1$, it follows by (9) that $E_t(V)=3$.

A comparison of these results for the rectangular parallelopiped with the results for the sphere in Example 3 shows that, under the assumptions of Formula (9), the elasticity of length is 1, that of area is 2, and that of volume is 3.

ORIGIN OF THE PLANETS

Planets such as our earth were created ages ago when the sun, in its voyage through space, passed through dense clouds of dust and gas, according to a theory advanced by the Swedish physicist, Dr. Hannes Alfven of the University, Uppsala.

Atoms in an interstellar cloud began falling toward the sun, became charged with electricity, and were sent spiralling away by the sun's magnetic field.

The charged matter began to rotate about the sun's axis at the distance where the gravitational pull of the sun exactly counter-balanced the repelling force of the sun's magnetic field. Different atoms were stopped at different distances and condensed to form the major planets such as Jupiter and Saturn, Dr. Alfven suggests in a series of papers published by the Stockholm Observatory.

Satellites and Saturn's rings were created from gas which failed to be captured when the planets were being formed. Attracted by the gravitational fields of the planets, the gas fell in toward the planets, became heated, ionized and was stopped by the magnetic fields at a critical distance from the planet. Jupiter's satellites, for instance, were created in this way.

With Saturn, the material which would otherwise form the first satellite was unable to condense and thus the spectacular ring system was created. With Neptune and Uranus, the mass of the planet is so small that the distance at which the matter would be stopped lies within the planet itself, so that neither satellites nor rings were created at this time.

Sun a Great Magnet

The magnetic pull of the sun at the time the planets were born must have been many times stronger than it is today, and the breeding sun probably rotated much more rapidly than it does at present. Mechanical forces, which have hitherto been the only ones considered, played a much less important part in the creation of the solar system than electromagnetic forces, Dr. Alfven estimates.

Having trouble with office woodwork? Add glue to water to wash. Glue is an excellent paint cleaner, and its "sizing" quality replaces the gloss which soap and water tends to dim. One half pound of powdered animal glue will clean a medium sized room. Add water to glue to make two quarts of liquid. Let stand over night. Boil this for 10 minutes stirring. Mix cup of this solution with small pan of water when washing paint. Do not rinse off but allow solution to dry on paint.

THE SELECTION OF BOOKS IN THE FIELD OF PHYSICS

MANNING M. PATTILLO, JR.
Presidio of San Francisco, California

Today's men of physics are successors to the philosophers of ancient Greece. Einstein, Millikan, Compton, Planck, Lawrence—these names bring to mind great works. Reasoning with mathematics, observing with the senses, measuring with mechanical and thermal instruments, physicists are solving the problems of philosophy and engineering.

One must look far and wide in the popular literature of physics to find a concise definition of the field, for writers realize that a statement about the old-time "natural philosophy" is too vague to be helpful and that a definition of the subject as it is today implies advances that modest men hesitate to claim. Physics, says the unevasive lexicographer, is "the science which deals with those phenomena of inanimate matter involving no changes in chemical composition or, more specifically, with the most general and fundamental of such phenomena, namely motion."[1]

In the spectrum of knowledge physics is bordered by mathematics and astronomy on one side and by chemistry on the other. Turning to its neighbors, it strives on the one hand for a perfectly mathematical formulation of its phenomena, and on the other, it co-operates in atomic research with chemistry, the study of composition. Each law of physics, that is, each law of motion, is expressed in a differential equation, combining in one statement the factors of space and time. The differential equation is an advantageous medium for the formulation of phenomena, because it is compact and precise, and because the deduction of consequences is most easily achieved through its use. The results of deduction are reconverted into physical terms for interpretation.

Partly for historical reasons, partly for convenience in study, physics is divided into seven branches: mechanics, heat, electricity, light, sound, radiations, and atomic structure. The link that connects these branches is ***motion***.

Having taken a glance at physics itself, we turn now to its literature. When we apply the adjective "best" to a physics

[1] *Webster's New International Dictionary*, 2d edition, unabridged.

book, or to any book for that matter, the question immediately arises, "Best for whom?" or "Best for what purpose?" We need a classification of the types of writing existent in the field. Inspection of a publisher's list of physics books or examination of the physics section of a large library suggests the following as appropriate categories for the literature of physics:

1. Popular interpretations
2. Serious, philosophical treatises
3. Elementary, general texbooks
4. Advanced textbooks
5. Laboratory manuals
6. Books of applied physics
7. Reference books.

In addition to the above classes of books, there are journals in which the results of physical research, the news of physicists, and reviews of scientific books appear. We, as selectors of books of physics, must consult the book reviews found in journals, but this paper is not concerned with the methods of selecting journals.

It is apparent that the standards for sound evaluation of books of physics must vary from category to category, because the books in each category were written for a unique purpose. Thus, the purpose of laboratory manuals of physics is to guide the user in the experimental study of physics. No other group of books has exactly this function. Our task, therefore, is to determine the criteria for judging how well a book accomplishes the purpose for which we want it. In the outline that follows, those standards applicable to *all* books have been omitted.

Popular interpretations of physics are written for the information and enjoyment of casual readers and of persons who lack the background necessary to understand technical books of physics. The achievement of this purpose depends on the possession of certain qualities.

Of first importance are:

1. Accuracy of information. This is the most important criterion.

2. Up-to-dateness of subject-matter. The rapid development of physics often makes this equivalent to accuracy. The following quotation from a review shows how quickly a book may become partly obsolete: "By way of conclusion the author calls

attention to the urgent need for solution of such problems as the multivalued electron-velocity situation which is characteristic of retarding field tubes, and the large-signal, high frequency theory of vacuum tubes. It is striking commentary on the speed with which technical advances are occasionally made that these problems have been solved since the book was printed."[2] Although this quotation comes from a review of an advanced book, the point holds also for popular interpretations.

3. The inclusion of a minimum of mathematics. Most readers understand no mathematics above simple algebra and simple geometry.

4. The assumption by the author that readers have no previous knowledge of physics. If technical terms are used, they should be defined or explained.

5. Clear, simple, adult language.

6. A carefully planned, substantial treatment of the subject. The day is gone when we had to accept in the name of science a mere gathering-together of unrelated, insignificant scraps of information of the "strange as it seems" variety.

Of second importance are:

1. Illustrations that help to clarify the text and add interest. These illustrations should adjoin the sections to which they apply; they should not be scattered at random through the book.

2. The promotion of interest through the use of biographical material or discussion of the implications of physics in daily life.

3. A table of contents, indicating to prospective readers the scope of the book.

4. A bibliography of similar books to which readers may go for additional information.

Serious, philosophical treatises on the aims, methods, development, and present state of physics comprise the second class. Books of this type are usually written by philosophers attempting to evaluate physics in broad terms or by mature physicists who, having dug deeply into special parts of the field, stop to look at physics in relation to the more general problems of epistemology and of the interpretation of the universe as a whole. These are books primarily *about* physics. The criteria

[2] From an unsigned review of the book *Electron-inertia Effects* by F. B. Llewellyn, which appeared in *Electronics* 15, 7, 94.

of the second category are few, but difficult for the author to satisfy and for the critic to apply.

Of first importance are:

1. New ideas or new emphases in the light of the latest findings in physics.
2. Adequate documentation. The foundations on which the treatise is based must be accurately established.
3. Careful definition of terms, particularly those used in more restricted senses by philosophers than by others.
4. Consistency with the best thought of philosophy as well as of physics. This calls for perspective and a catholicity of outlook.

Of second importance are:

1. A table of contents to indicate the scope of the book. A preface is also helpful for the same purpose.
2. A detailed index to increase the reference value of the book.
3. An extensive bibliography, pointing the way to further reading on the subject.

ELEMENTARY, GENERAL TEXTBOOKS of physics are used in introductory courses in high schools and colleges. Often a book of this category is tested for several years in the author's classes before publication. This aging process results in greater accuracy and clarity. Teachers, as well as librarians, are interested in the features that distinguish good textbooks of physics from inferior works of the same type.

Of first importance are:

1. The use of no mathematics above the high school level, but extensive application of high school mathematics to the problems of physics.
2. Emphasis on basic principles. The use of smaller print to separate the less important material from the more important is helpful.
3. Comprehensiveness. At least one chapter should be devoted to each branch of physics.
4. Up-to-dateness. The fundamentals of physics are not a fixed body of information to be handed from one generation to the next. Basic physics is constantly undergoing modification.
5. Accuracy. Oversimplification amounts to inaccuracy.

6. Careful definition of terms peculiar to physics.

7. Uniform, meaningful diagrams adjoining the sections to which they pertain.

8. Well-proportioned treatment of topics, according to importance and difficulty.

9. Illustrative solutions to show how physical principles can be applied to actual problems.

Of second importance are:

1. Abbreviations and symbols in accordance with the recommendations of the Committee of the American Association of Physics Teachers.

2. Problems to test the student's understanding of the subject-matter and to provide practice in applying principles.

3. Special attention to applications within the reader's experience. This adds interest to the study of physics.

4. A table of contents to help teachers in planning courses.

Of third importance are:

1. Prefatory suggestions to teachers.

2. A glossary of physical terms.

3. Attractive and descriptive illustrations of physical apparatus and of great physicists.

ADVANCED TEXTBOOKS constitute a fourth category in the literature of physics. This class differs from the third in being a group of specialized books which require for their comprehension a knowledge of college mathematics and of introductory physics. The criteria of the two categories reflect these differences.

Of the first importance are:

1. The inclusion of the latest findings in the field. The author must rely upon reports in physical journals, as well as upon his own research.

2. Accuracy of information, insofar as it is possible. In books that represent pioneering efforts, absolute accuracy is neither attainable nor necessary; development in physics would be greatly hampered, if no new method or theory could be published until it had been proved beyond doubt.

3. Careful definition of terms new to the student.

4. Uniform, helpful diagrams placed where they are needed.

5. Emphasis on the relation of the branch of physics under

consideration to other branches of physics and on their interdependence.

Of second importance are:

1. An index to increase the reference value of the book.
2. A carefully drawn-up bibliography.
3. A preface giving the scope, the aim, and the viewpoint of the book.
4. The use of conventional abbreviations and symbols.
5. Problems to test the student's understanding of the subject-matter.

LABORATORY MANUALS are used as guides in the experimental study of physics. Observation and measurement are absolutely necessary to the investigation of physical phenomena. It is important, therefore, that students of physics be provided with adequate instruction in these methods. The criteria of laboratory manuals of physics are as follows:

Of first importance are:

1. Explicit and accurate directions for performing the experiments. Explicit directions are particularly important in elementary manuals in order to save time for the immature student. In all manuals, however, avoidance of the "cook-book style" is desirable.
2. The requirement of easily obtained apparatus only, so that the manual may be used in even the simplest laboratories.
3. A sufficient number and variety of experiments to enable teachers to adapt the manual to different types of classes and to courses of varying laboratory time-allowance.
4. The use of conventional abbreviations and symbols.
5. The inclusion of thought questions to help the student integrate his theoretical and experimental studies.
6. A brief introduction to each experiment. To derive the greatest profit from laboratory work, the student must know the purpose of each experiment.
7. The same order of topics as is generally followed in textbooks with which the manual is likely to be used. This is necessary so that the laboratory work, as prescribed in the laboratory manual, will parallel the reading the student does in his textbook.
8. Up-to-dateness. There should be experiments illustrative of the latest developments in the field, as far as that is practicable.

9. The same mathematics and physics prerequisites as required for the comprehension of textbooks with which the manual is likely to be used.

Of second importance are:

1. Perforated pages, so that the report for each experiment may be submitted to the instructor for correction.
2. Spaces provided at the head of each report for the name and desk number of the student and the date of the experiment.

Of third importance are:

1. A table of contents.
2. References to several different textbooks for parallel reading. Teachers sometimes wish to use a textbook by one author, a laboratory manual by another.
3. Prefatory suggestions to the instructor on the best use of the manual.

BOOKS OF APPLIED PHYSICS are in great demand today. There is an abundance of books of this type on radio and photography. It is difficult to draw a line between this category and books of engineering or between this category and advanced textbooks of physics. For the purposes of this discussion let us consider books of applied physics as more elementary in approach than the books of either of the other two classes. Even assuming this arbitrary distinction, it is evident that the sixth category is a heterogeneous group, containing both technical and near-popular works. The criteria are as follows:

Of first importance are:

1. Up-to-dateness. Progress in the laboratory is quickly translated into improved shop and factory methods.
2. Accuracy of information.
3. Specific demonstration of the applicability of physics to the field under consideration.
4. Problems to test the student's understanding of the subject-matter. This criterion applies only to the more technical books in the category. Obviously, a small handbook on photography written for the person who has just bought his first camera is not improved by the inclusion of problems.
5. Self-teachability. Many users of books of applied physics do not have teachers at hand to explain difficult points.
6. An index to increase the reference value of the book.

7. The requirement of no mathematics above the high school level.

8. Sufficient theoretical information provided, so that readers without previous knowledge of physics may be able to profit from the book.

9. Uniform diagrams that clarify the text. These should appear on the same pages as the sections to which they pertain.

10. The inclusion of helpful data for reference purposes. These data normally appear in the back of the book.

Of second importance are:

1. A bibliography to guide the reader in further study of the same subject.

2. The use of conventional abbreviations and symbols.

3. A book title and chapter titles that are descriptive of the contents.

REFERENCE BOOKS of physics, meaning especially dictionaries and collections of tables of physical data, form the last category. Books of this type are consulted by persons who need specific information and are found wherever physicists are working. The criteria are all of the first importance.

1. Accuracy. For a reference book of physics to be accurate, it must be recent. If the book is a serial, it should be examined to ascertain whether or not the revision has been thorough.

2. Completeness.

3. A detailed index to help locate the desired information.

4. The use of conventional abbreviations and symbols.

Let us not take lightly our task of selection.[3] Libraries cannot afford to order books that fail to serve good purposes. Books on physics are very expensive. Readers of physics are serious readers. These important facts demand judicious selection of books in the field of physics.

SUPPLEMENTARY DATA

Important publishers of physics books: McGraw-Hill, Macmillan, Van Nostrand, Wiley; also Bell, Blackie, Blakiston, Cambridge, Chapman, Ginn, Holt, Longmans, and Oxford.

Some important aids in the selection of books in the field of physics: Journal of Applied Physics; Astrophysical Journal; Electrical World; Electronics; Journal of the Franklin Institute; London Edinburgh & Dublin Philo-

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[3] For a discussion of selection in another field see the author's article *The Selection of Books in the Field of Mathematics* in *School Science and Mathematics*, May 1943, 468. A similar article by the same writer, entitled *The Selection of Books in the Field of Chemistry*, which appeared in this journal recently (Dec. 1944, 845), applies the same method of evaluation to chemistry books.

sophical Magazine and Journal of Science; Nature (London); New Technical Books (New York Public Library); Journal of Physical Chemistry; Scientific American; Review of Scientific Instruments; Scientific Monthly; Technical Book Review Index.

The material of this paper has been drawn from reviews in the above publications and others, from personal experience and thinking, and from examination of a large number of books of physics. Helpful for information about physics itself were the following:

Lodge, (Sir) Oliver Joseph. "Physics." In *The Encyclopaedia Britannica*, 14th ed., 17, 880–883.

Darrow, Karl Kelchner. *The Renaissance of Physics*. Macmillan, 1936. 1–18.

Planck, Max. *The Universe in the Light of Modern Physics*. Norton, 1931.

DDT AGAIN

An interview with shy, young Dr. Paul Muller of the J. R. Geigy Company, Switzerland, to whom the world owes a debt for the discovery of the insecticidal properties of DDT, and tall, suave Dr. Paul Laüger, Director of Research there, brought forth some interesting information regarding DDT.

DDT, as everyone now knows, is a contact poison. What is not so well known is that the skin of insects contains a lipoid layer (a protective coating acting in some ways, like a raincoat) and DDT goes into solution in this layer. From there it attacks the nervous system of the insect. The skin of warm-blooded animals is entirely different, and since it does not include this lipoid layer, DDT does not have the same or even a similar effect on man or other warm-blooded animals. True, a sufficient quantity of DDT swallowed or absorbed through the skin of a warm-blooded animal will cause trouble, but real danger is actually slight. Workers in plants where DDT powder is made are constantly sprinkled with the dust, with no untoward effects. When DDT is mixed with carriers that do not evaporate quickly, such as kerosene, and applied to the skin, contact is maintained for a long time and irritation may result. Birds can get enough DDT internally by eating poisoned insects to be harmed or even killed. Bees, being insects, are killed by contact with DDT.

The problem of the carrier is of primary importance. Molecules of DDT separated from each other have more chance to attack. The DDT molecule bristles with chlorine atoms, and these are the key to its action. The freer the chlorines are to reach the surface, the more efficiently they can work—effectiveness of DDT depends on its dispersal through a carrier. For this reason, a 5% solution of DDT is much more effective than a 100% powder. By careful choice of the type of carrier and regulation of the percentage of DDT, researchers hope eventually to be able to provide highly specific insecticides. It might then be possible to eliminate "bad" insects in a given area while leaving the useful ones undisturbed. Perhaps these modifications will make available products not in the least potentially dangerous to people, pets or livestock.

Without courage there cannot be truth, and without truth there can be no other virtue.—*Sir Walter Scott.*

REMAGNETIZATION OF U-MAGNETS AGAIN

LUTHER C. DAVISSON
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On page 79 of the January, 1945, edition of SCHOOL SCIENCE AND MATHEMATICS is an excellent short article by Joseph A. Mack giving instructions for remagnetizing old U-magnets or bar magnets. These instructions are good but many teachers in small high schools do not have the rectifier nor the specially constructed coil. But these are not necessary. All that is needed is a spool of double cotton covered wire, say No. 18, of about 200 turns or more, with a hole large enough to allow one arm of the magnet to enter. (If the hole in the spool is not large enough it can easily be enlarged with a drill or a round file.)

Connect one terminal of the wire from the spool to a binding post or a nail in a dry board. Drive a second nail into the board an inch or two from the first one. Connect one terminal of a lamp cord from a plug to the second nail and the other terminal to the second end of the wire from the spool. Join the two wire terminals attached to the nails by a small piece of tin foil $\frac{1}{4}''$ by $1\frac{1}{2}''$, or by a short piece of light fuse wire of 2 to 5 amperes capacity. Insert the plug in the socket of a regular AC line, then turn on the switch. "Pif" goes the fuse wire or tin foil and the magnet is remagnetized. Turn off the lamp socket to avoid trouble. Withdraw the magnet now completely magnetized and everything is in readiness to insert another magnet, add another bit of tin foil or fuse wire, and proceed as before. The students will want to magnetize some old files, large needles, etc. for their own use.

In the tannery trade, hides are shaved and buffed with coated abrasives. The most efficient machine uses a roll covered with a paper backed animal glue bond abrasive wound spirally. A rubber roll runs parallel to this roll and regulates the amount of cut by pressure. So accurate is this machine that we can feed a newspaper through the shaving machine and cut the print from it without tearing the paper.

Graining rollers, similar to printing rollers, are used to transfer a wood grain design from a zinc plate to a sheet of metal which is later formed into dashboards and interior trims. Same application is used on Pullman cars, metal furniture, stoves and other metal products enhanced by a wood grain design.

THE PEDAGOGY OF MATHEMATICS

Ovid W. Eshbach
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Some four years ago, when the training of military specialists became an urgent necessity, claim to the discovery of weakness of education in science and mathematics in secondary schools was widespread. Criticisms were not confined to secondary schools. Colleges and universities came in for their share of it, although an analysis of the complaints made it quite obvious that most people were talking about arithmetic and algebra. Also apparent was a lack of accurate conception of the common physical terms popularly used in talking about our physical environment and material progress. This observation did not come as a shock or a surprise to engineering educators. It has been known for a long time.

Just previous to the recent war the Technological Institute had an opportunity to give an examination to a highly selected group of freshmen, and in cooperation with another institution giving the same examination, to compare the results. The test was not difficult and could have been answered perfectly by an exceptionally good student without the use of a lead pencil in approximately thirty minutes. A surprising number of these students, who generally stood in the upper quarter of their high school class, made less than twenty per cent on the test, although the average grade was a poor passing mark. The experiment was repeated the following year with similar results. A few years later, employing the same methods of selection, comparative tests of a different type were made with twenty-three engineering schools and showed that the group we had been selecting were decidedly among the very best freshmen admitted to engineering schools.

Those who have had long experience in education recognize that new things are learned slowly and retained only after repeated use. It is probably unfair to draw harsh conclusions from the results of tests given after a summer's vacation. In an attempt, therefore, to be fair, the sequel to the story should be told. During the first year slightly over a quarter of the students withdrew. One half of those who withdrew did so because of failure to carry the work. The object of the tests obviously was to segregate students so that they could begin their college

mathematics at a place where they were capable of carrying the work. The records of all of them indicated that they had superior intelligence and that they had had a minimum of three years of preparation in secondary school mathematics. Most of them had had four years. But there was nothing in the examination which was not covered in the first year of instruction in algebra. Four years later approximately fifty per cent of the entering class graduated, notwithstanding some attrition due to war enlistments, although deferments for engineering students were in effect at that time. Most of them are officers in the Navy and Army and have made an outstanding record in the most technical phases of the war effort.

The objective experience just recited is a confirmation of a conviction current among engineering educators for as long as I can remember. First, the basic instruction in secondary school mathematics is not what it should be. Second, the corrective measures necessary on the college level seriously handicap an effective or high quality program of technical education. It is for these reasons that I welcome the opportunity to say something about the pedagogy of mathematics. Today there are few engineering schools who may enjoy the privilege of assuming an adequate preparation in mathematics, and almost none who do not have to employ some corrective measures, thus delaying instruction vital to the understanding of introductory engineering subjects. In many places the natural consequence is that college physics is taught on a high school level and the more advanced instruction of a professional nature delayed, causing a congestion of material in the upper years.

Looking to the future, we should anticipate and strive for a collegiate program of technical education, both in engineering and science, on a higher intellectual and more fundamental level than ever before. The culture of our generation has seen an expanding utilization of the knowledge of science which will continue indefinitely in the postwar period. It is not possible to give the degree of professional competence which men in practice would like to see a college graduate attain, but with the synthesis of knowledge in related fields of science it is possible to lay so broad and sound a foundation that a high degree of competence may be expected in a reasonably short postgraduate period of employment and specialization. Part of the educational burden always has rested with American industry and always will. It is also inevitable that the appreciation of the

values of industrial research will create a greater demand for a longer education involving larger enrollments in post-graduate work. This trend was quite noticeable prior to the recent war, although it unquestionably was stimulated by the depression period when getting an education was the best thing to do.

Having stated the problem, I should like to make suggestions on the general education of secondary school students, their preparation in mathematics, and some needed improvements in collegiate instruction in mathematics. In making a recommendation on general preparation, nothing is included which is not possible of achievement, for it is now being done in the best secondary schools. To provide a suitable preparation, the following subjects are recommended: English: Four years. Foreign languages: Modern languages, particularly French and German, are preferred; Two or more years in any of the following are recommended: French, German, Spanish, Russian Latin, Greek. Mathematics: Two years of algebra, plane and solid geometry, and trigonometry. Science: physics, chemistry, and biology or general science. History: American history and civics; ancient, medieval and modern world history. It will be noted that considerable emphasis is placed on language. After all, this is our conventional method of expression, and a student who cannot read fluently is handicapped in developing good study habits, in the rapid acquisition of knowledge, and in the pleasure derived in study. In science and technology modern foreign languages are important, but the most important language is the symbol language of mathematics.

Here in brief shorthand form are written the truths or laws of nature. The ability to recognize symbolic relationships and to draw conclusions from them is a goal just as important as learning the conventional methods of manipulation. In saying that four years of secondary school mathematics is a minimum that any technical school should accept for admission, I do not believe that this is the most important problem. By far the more difficult one is the development of the most effective methods of acquiring mathematical proficiency. Skill in the manipulation of algebraic quantities is basic to the use of this symbol language As a rule, students do not fail in higher mathematics because of the difficult concepts of the calculus. They fail because of an inability to recognize relationships between rather simple concepts when expressed in symbol form. A thorough drill in all the manipulative processes is essential. This does not mean,

however, that emphasis should be confined to algebra only, nor does it mean that we need permanently consider the segregation of geometry, trigonometry and algebra as the only way of learning mathematics. The arrangement of subject matter is perhaps secondary to the development of analytical or thought processes in the learning of it. For example, it is not sufficient to solve a set-up problem by *ad hoc* methods of solution but, rather, extended drill should be given in setting up the problem in symbol form from known physical facts, solving it, and interpreting the results. One of the most effective training techniques, that of mental arithmetic, has practically disappeared in our present educational process. Extemporaneous or oral analysis, including a plan of solution of a given problem, should be employed to a much greater extent. Far greater emphasis should be placed on what are sometimes called reading problems, to develop ability in the student to state (1) what the problem says, (2) what the problem wants to know, and (3) the method of solution.

Science and technology is to a large measure the art of solving problems. The ability to state the problem, determine the objective, and discover a method of solution is the goal sought in all stages of instruction in mathematics. To acquire these objectives, texts should be well chosen. For example, there are about a hundred fairly widely used texts in trigonometry. I have examined a number of these, and in one that I remember quite well the relationship, $a^2+b^2=c^2$, appeared for the first time on page 100. When it is considered that all that is new in the subject of plane trigonometry can be completely explained in one afternoon and probably written on as few as ten pages, one cannot help but feel a lack of tolerance for the zealousness, or verbosity of textbook writers. Good technique in writing and, teaching will explain new and fundamental things in simple, concise language, and follow these explanations with extended applications to fix the concept in the student's mind and also the manner in which it can be used. Algebra and geometry books are less susceptible to criticism, although not much improvement has been made for over fifty years. Instruction in mathematics on a college level is even more vulnerable. With few exceptions, teachers have been slaves to published texts. For example, the chronological order of teaching analytical geometry, differential calculus, integral calculus, and differential equations is an accepted practice in most institutions. The time

allocated is usually the first two years, which means that any use of the definite integral or differential equations in the study of mechanics, electricity and heat must either be avoided or time taken to explain the simple operations involved. A few efforts have been made to introduce these fundamental concepts in first courses in mathematical analysis. The most general criticism of these attempts is a failure to develop proficiency in the operational use of the calculus as early as it should be acquired, so that to date there is no adequate text material to accomplish both of these highly desirable objectives. To do so would probably require the continued effort of qualified persons over at least a five-year period, and even if accomplished, it might be futile to put it into effect unless a higher level of proficiency in the things they are now studying could be expected from high school graduates.

In trying to present this problem in simple language I realize that it is inadequately explored and that time is not available to fully discuss its implications. Because it is one of the most important, if not the most important, in the development of future educational programs in science and engineering it is pertinent to discuss its relation to the broader purposes or objectives of education. Professional careers differing widely in their demands for specific techniques and fields of knowledge are alike in one respect. Success in any field depends upon ability to cope with the multitude of diversified problems which arise continually and require rapid and accurate solution.

The value of an educational process is not to be measured alone by the quantity of information it imparts but by the flexibility or versatility which it develops as well. The vital requisite is a disciplined mind with the perspective, the judgment and the ingenuity necessary to derive the greatest possible value from the information available. Consequently, it is of the greatest importance early in the educational process that strenuous effort be devoted to creating a facility for clear and logical thinking. The objective should be the proper orientation of the student's point of view and the conditioning of his mental processes. Subsequent accumulation of factual knowledge is accomplished much more easily and effectively by a well coordinated mind.

The arts are the "know how" of doing. Applied mathematics and science are examples of the advanced arts, as is applied English—the ability to write with clarity and brevity. Much

of the content of a professional education is knowing how to do things. It is the ability to apply mental and manual dexterity and to plan and direct the attack upon a problem. It cannot be learned by reading alone but must be acquired under competent guidance and direction, with opportunity for the student to develop his creative talents. The future will demand both knowledge and the arts at high levels of attainment. Mathematics is a supporting structure linking knowledge and the arts. It enhances the comprehension of information, facts, and theories, and the interrelationships between them. It contributes to the acquisition of knowledge through the exercise of self-discipline and the development of good habits of study. The methods of acquisition are often more important than the knowledge itself.

Perhaps the greatest weakness in all of our mathematical instruction is the failure to relate mathematical equations to physical realities. Symbols used in algebra, trigonometry, analytical geometry and calculus have usually stood for numbers only, not for physical magnitudes specified in terms of units of measure and the number of times the units are taken. Thus, students fail to grasp the meaning of mathematical equations. They know only in part, and art becomes merely skill in meaningless manipulations. One of our staff recently drew the interesting conclusion that much of mathematical instruction given students in our present courses tends to develop forms of insanity, and justified his statement by saying that insanity is caused and characterized by the failure of a person's thoughts and actions to correspond to observable reality. Hence his actions, based on false attitudes and beliefs, are more or less irrelevant or inimical to successful adjustment to his physical and social environment. Analogously, in mathematics, students fail to understand the relation between mathematical symbols and the realities for which they stand. Hence their actions in applying such knowledge are likely to be irrelevant or false to the situation.

Sound judgment and common sense, which govern the way in which knowledge and the arts are applied to any particular situation, are usually described by the word "wisdom." It embodies the ability to appraise a set of circumstances, to foresee their implications, and to initiate action which will assure attainment of desired ends. I think we would agree that for the most part it depends on inherent aptitude or native intelligence

and its possession is not necessarily a monopoly of those who have had a formal education. But education, and particularly a good mathematical education, can be significant in its development. Experience in material and human environments enriches the faculty of wisdom and enhances social behavior—the attitude of the individual towards others. We frequently refer to this by-product of education and experience as manners or personality. Its development may be enhanced to a large degree through example and advice to students by members of the faculty who themselves have attained a high level of social behavior. Home and community influences, supplemented by studies in history, philosophy, economics and sociology, are ordinarily thought of as making the greatest contribution to a student's understanding of his obligations to society and his cultural behavior. Mathematics should not be overlooked, for an unconscious by-product of its discipline, when taught in a proper stimulating manner, produces a consciousness of social obligation and the indispensability of personal integrity and responsibility in dealing with others.

Thus, mathematics is a force in our educational process, in the achievement of art, knowledge, wisdom and culture. Too frequently the methods of pedagogy follow a policy of appeasement of the forces for mediocrity. Those in the profession are faced with a challenge comparable to the most interesting and fascinating development of instruction in any other subject.

ANRAC, WAR-BORN ROBOT CONTROL

ANRAC is the newest addition to the now-it-can-be-told family of electronic devices developed during the war that are being put to peacetime uses. ANRAC is a system for turning on and off such aids to navigation as unmanned lighthouses, light buoys, foghorns and electric bell strikers by means of a set of coded radio signals sent out from a central control station. The word was coined from the initials of Aids Navigation RAdio Control.

The system was installed by the U. S. Coast Guard at Pearl Harbor, Midway, sections of Alaska and certain islands in the South Pacific, as well as along both coasts of the continental United States, so that navigation aids could be turned on for the benefit of friendly vessels and shut off at other times to deny any involuntary aid to the enemy.

Peacetime uses are expected to be largely in the direction of economies in operation, permitting lights to be turned on and off according to natural lighting conditions, bells and foghorns to be stopped when there is no fog, etc. An added benefit, in the case of foghorns, is the abatement of their nuisance character; residents on foggy coasts become resentful if a foghorn keeps right on with its monotonous, disagreeable sound after the fog has cleared.

THE QUIZ SECTION

Julius Sumner Miller

Chapman College, Los Angeles 27, California

1. Plants liberate some carbon dioxide when in darkness, but the amount they absorb in sunlight exceeds their nocturnal yield. (T or F)
2. Identify: "Mortals, congratulate yourselves that so great a man has lived for the honor of the human race."
3. An ocean of mercury 30 inches deep all over the earth would have the same weight as the atmosphere. (T or F)
4. Five straight lines (none parallel) have as many intersections as they form triangles. (T or F). (Hugo Brandt, Chicago.)
5. Can a six-foot man see his whole figure in a three-foot mirror?
6. If g (acceleration of gravity) on the moon is roughly one-sixth that on the earth, on the moon a body requires $\sqrt{6}$ times as long to fall from a given height. (T or F)
7. Without actual calculation, approximate (guess!) rapidly the weight of a huge ball of cork, 20 feet in diameter.
8. The stalactite grows ***down*** from the ceiling; the stalagmite rises ***up from*** the floor. (T or F)
9. When transplanting, why is shrubbery pruned?
10. Arrange in proper order: phylum, class, order, family, genus, species.
11. $10^{19} < 2^{64} < 2 \cdot 10^{19}$. (T or F). (Hugo Brandt, Chicago.)

ANSWERS TO THE QUIZ SECTION

1. T; 2. Inscription on Newton's tomb; 3. T; 4. T; 5. Yes; 6. T; 7. about 26 tons!; 8. T; 9. The leaf area is reduced by pruning in order to reduce evaporation; 10. Correct as stands; 11. T.

WHEN IS A TOMATO NOT?

There was a time when a tomato on the menu was a tomato, and vitamin C could be crossed off for the day. But the information has been gradually getting around that there are tomatoes and tomatoes, in respect to vitamin C content, and now the housewife has a whole new set of diet factors to worry about. Light intensity; climate and the soil in which fruits and vegetables are grown, are found to make a great deal of difference in the nutritional value of a crop.

Housewives are not the only ones who must consider these findings. Farmers and agricultural research workers used to have one primary goal—higher yields, greater production per acre. Then came the discovery that quality may be sacrificed for quantity. First improvements in quality centered about increased resistance to disease, attractiveness, palatability, shipping qualities, etc. Recently agricultural scientists have concentrated on improving the nutritive quality of farm products.

Since domestic animals depend almost entirely on foods derived from plants and since more than 60% of man's diet is also of plant origin, the U. S. Plant, Soil & Nutrition Laboratory was set up at Cornell to study the problem. Although you will probably never buy food with a soil or climate pedigree, these studies should lead to a better knowledge of all factors affecting the variability in nutritive value of food plants, and help in stepping up the percentage of the more valuable ingredients.

AERONAUTICAL INSTRUMENTS PROJECTS

WALTER B. WEBER
State Teachers College, Buffalo, N. Y.

"Keep em Flying" is the far reaching cry of the new air age. The future of our country depends upon our ability to command the air, and this responsibility rests in the hands of the youth of today.

In keeping with the demands of the United States Government, the U. S. Department of Education has advocated courses in pre-flight training for the secondary school students. Not all high schools have qualified instructors, nor are they fully equipped to teach pre-flight training. However, if the high schools are to keep abreast of the times, they must sponsor and provide environment whereby the youths of the nation may know the possibilities, opportunities and requirements for successful living in our new era.

Every high school science teacher is familiar with the facts that in the past storms, clouds, fogs and mountains were serious handicaps to flying, and that today these drawbacks to aviation have been overcome by the knowledge and use of a maze of weather, engine, navigation and radio instruments.

The author has used this knowledge to bring to his students an interesting and practical explanation of these primary instruments. More important, however, is the fact that the students helped design and build many of these instruments. They are based upon the theory of actual operation and each functions as a piece of demonstration apparatus.

Real aircraft instruments require watchmakers skill and therefore would make it prohibitive for students to take them apart for examination. It is also impossible to obtain aircraft instruments because of the high priority and excessive cost.

These instruments were built almost entirely from scrap or discarded materials. A roller skate wheel was used for the bearing of the wind vane, an old bicycle wheel for an anemometer, an automobile hot water thermostat control for an altimeter and rate of climb instruments, a toy gyroscope for the artificial horizon, and so on through the list.

The following method of instruction was employed: A rough sketch of an instrument was placed on the blackboard and the theory, use and operation was explained. The students took

notes and made working drawings, incorporating their own ideas. A few of the best designs were selected and built. After some experimenting and testing of the best models one was chosen and more substantially built, which is now used for demonstrating the principle and operation of the instrument. All students contributed their knowledge and skill to the ultimate construction of each instrument.

The instruments listed below have all been built and tested and found satisfactory for the field and purpose for which they were intended. It was hoped that in the construction and testing of these projects, the understanding of the fundamental principals involved would provide, in a small measure, those assets which will make our future generation the finest equipped in the world for the new air age.

The instruments made in the laboratory include the Magnetic Compass, Altimeter, Rate of Climb, Magnetic Tachometer, Artificial Horizon, Rate of Turn, Bank Indicator, Air Speed Indicator, Fuel Level Gauge, Vapor Pressure Temperature Gauge, Exhaust Analyzer, Oil Pressure Gauge, Simple Rain Gauge, Tipping Bucket Rain Gauge, Simple Rotating Anemometer, Mercurial Barometer, Sling Psychrometer, Simple Wind Vane, Three Types of Radio Code Practice Sets.

The value of this activity may be ascertained by a review of the scientific principles involved in the operation of these instruments. The following is a brief summary of these principles.

COMPASS.

Principle of attraction and repulsion of magnetic poles. Magnetic variation and deviation. Magnetic dip. Cardinal points.

ALTIMETER AND RATE OF CLIMB.

Aneroid and mercurical barometers. Barometric pressure. Pounds per. square inch. Varying pressure with altitude. Expansion and contraction of metals. Weight of liquids. Capillary leak.

TACHOMETERS: MAGNETIC AND GOVERNOR TYPE

Magnetic induction and drag. Eddy currents. Centrifugal force.

ARTIFICIAL HORIZON. GYRO COMPASS. RATE OF TURN. VENTURI TUBE AND VACUUM PUMP.

Gyroscopic principle of rigidity. Perfect balance. Venturi tube action. Cylinder and piston action.

BANK INDICATOR.

Principle of pendulous devices. Damping action of liquids. Law of centripetal force.

AIR SPEED INDICATOR.

Static and impact pressure. Pitot Static Tube. Principle of levers and dials.

FUEL LEVEL GAUGE.

Principle of the potentiometer circuit. Electric meters.

TEMPERATURE GAUGES—VAPOR PRESSURE AND ELECTRICAL.

Principle of the Bourdon tube. Fahrenheit and centigrade. Temperature calibration. Thermo couple. Thermo E.M.F. of different metal combinations.

EXHAUST ANALYZER—FUEL AIR RATIO METER.

Principle of Wheatstone bridge circuit. Ratio of heat conductivity of H_2 and CO_2.

POSITION INDICATOR.

Electric lamp and switch circuit.

OIL PRESSURE GAUGE—GEAR AND PISTON TYPE.

Gear and piston action. Pounds per. square inch. Automatic relief valve.

RAIN GAUGES.

Use of milliliters. Calculating cubical content.

ANEMOMETERS.

Velocity. Miles per hour. Wind pressure. Air speed. Admiral Beaufort's Scale.

SLING PSYCHROMETER.

Relative humidity. Evaporation and precipitation. Dew point. Water vapor. etc.

WIND VANES.

Compass rose. Wind direction and drift. Wind sock. Remote indication by electro and solenoid magnets. Commutator segments.

RADIO CODE PRACTICE SETS.

Principle of high frequency buzzer. Radio tube operation. Filament, grid, plate circuits A.B.C. Power supplies. Oscillating circuits. Transformers. Ear phones. Resistors. Condensors. Neon tube. Simple electric circuits.

Weather and radio instruments were included because they are becoming more and more important to aviation. A knowledge of the construction, operation and use of weather, navigation, engine and radio instruments may be an entering wedge for a career in aviation.

Further information may be obtained by writing to Walter B. Weber at State Teachers College, Buffalo, N. Y.

THE MOST POWERFUL AIRPLANE ENGINE

Details relative to the most powerful aircraft engine developed and in production anywhere in the world have been released here. It is the 28-cylinder, 3650 combat horsepower, Pratt & Whitney Wasp Major, designed particularly for big long-range airplanes. With the war over, production is continuing because it will be the power plant in many giant new airliners.

The 28 cylinders of the Wasp Major are arranged in four rows of seven cylinders each, giving the engine a frontal area no greater than that of the 18-cylinder engine put out by the same company. The new engine is only one inch larger in diameter than the original 410 horsepower Wasp, built in 1925. Excellent cooling characteristics result from a helical arrangement of the cylinders about the crankcase.

The giant engine has deep-finned, forged aluminum cylinder heads and duralumin cylinder muffs of special design; scientifically correct cylinder cooling baffles; the elimination of the conventional ignition harness through the use of seven interchangeable magnetos; and an improved automatically-controlled, hydraulically-driven, variable speed supercharger.

OBJECTIVES OF SCIENCE TEACHING

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It is with a deep sense of humility that I, who have never taught in high school and am not eligible to do so, presume to address this group of experienced secondary school teachers on a subject so hoary as the one which I have chosen. At first thought, it seems incredible that anything both new and constructive could be said about "objectives of science teaching."

By rushing in where a wiser person probably would have feared to tread I have classified myself as a consultant, one who has been defined as "a man away from home who is telling you about something which you understand much more throughly than he does." Nevertheless, the custom of employing consultants persists, and one must presume that we are in some degree useful or it would not. One of my engineering friends explained the value of a famous chemical consultant as being due to his skill in arousing antipathy to his own unorthodox views. The effect is to stir up a great many good research ideas which are incidental to an effort to prove the consultant wrong. If you can get a group as intelligent as this one thinking hard about an important issue, that, alone, is worth a great deal of effort.

In view of the undoubted fact that high school graduates dominate the political thinking of the United States I wish to call your attention to the incontrovertible fact that this nation is, of all the leading world powers, the one most blind and stupid in its attitude toward science. If documentary evidence on this subject is needed, I refer you to the Bush Report, "Science the Endless Frontier," as abstracted in the September issue of *Fortune*. "Neither our allies nor, so far as we know, our enemies have done anything so radical as . . . to suspend almost completely their educational activities in scientific pursuits during the war period."

Having just witnessed the fact that a scientific development is capable of bringing to a sudden end the greatest war in history, one might suppose that almost anyone with intelligence above the moronic could understand the importance of trying to regain some of the ground lost during the war while other nations went rapidly ahead and we almost stood still. Instead,

we find the Congress seriously listening to proposals to interrupt the scientific education of every American young man who is physically fit. Let us not deceive ourselves; the proposed military training regulations mean far more than taking a year away from a man's scientific preparation. During a year in the Army a very great deal will be forgotten of what was known when the training period began. A man who has spent a year learning to let others do his thinking for him, learning to obey orders rather than originate ideas may be a very different person from the one who entered the Army. The point is that such regulations are proposed by patriotic men who think that they are doing the very best thing possible for the security of the United States. They are the men who in 1920 scoffed at the idea that airpower would be a decisive factor in World War II and who are now saying that atomic bombs are "just another weapon."

What I am suggesting is that we who teach science have a share in the responsibility for what is now happening. What have we been doing to give our students and the general public an adequate idea of what science can accomplish and how research is carried out?

To great sections of the American public, science is magic. A scientist is a man in a white coat who stares at the light through a test tube and solves any problem quickly—as in the movies. Have you told your classes that Salvarsan received the number "606" because 605 other compounds had been tested and found of little or no value as anti-syphilitics? Recently a booklet was published by an oil company containing an address by the late Thomas Midgeley, inventor of Ethyl gasoline, in which he pointed out that regarding science as magic results in public distrust of scientists and science because the public does not understand magic and fears what it fails to understand. On the outside of the booklet was a picture of a genie from the Arabian Nights rising out of a test tube!

Recently an excellent review of the story of pencillin was published under the title "Yellow Magic." Aside from the fact that pure penicillin is white, no more inappropriate title could have been selected. For the implications of the magic idea are perfectly clear: if science is magic, then you certainly do not need very many scientists; one in each field should be enough.

Have we ever given our classes the idea that science progresses mostly through a series of lucky accidents? There is enough

truth in this idea to make it really dangerous. We never can forget the story of the man who tried and tried to oxidize naphthalene to phthalic anhydride by means of fuming sulfuric acid and never succeeded until he broke his thermometer and the mercury proved to be the best catalyst for the reaction. There is no possible objection to this story if you are careful to point out that catalysis is one of the relatively few branches of science which are chiefly empirical, and if you give proper emphasis to the fact that it was a long, tedious, painstaking research.

For the implications of the lucky accident idea also are very clear: an accident can happen to anyone, so is scientific training really so very important? Should we not point out that it takes a very great deal of hard work and study to develop to the point where a man or woman can take advantage of a lucky accident? Fleming was not the only man, or even the first one, to observe the phenomenon of anti-biotic activity. He had the knowledge and genius to recognize the importance of the accident when a spore of *Penicillium notatum* floated through the air on to his culture of *Staph. aureus* and inhibited the growth of those repulsive little organisms.

It obviously is unfair to attribute all of the foolishness in the American attitude toward science to the shortcomings of the public school system. In spite of outstandingly brilliant expositions of the careers of such great scientists as Louis Pasteur and Madame Curie, the current confusion about the "secret" of the atomic bomb must be blamed partly upon a horde of grade B pictures whose plot centered about a secret formula. The scientist who makes the earth-shaking invention or discovery is always incapable of remembering or repeating it, and if he loses a scrap of paper on which the formula is written, posterity is threatened with an irretrievable loss. All this seems too silly to be taken seriously but I can see no escape from the conclusion that American attitudes are very greatly influenced by what the public sees in the motion pictures. Do you suppose that the crowded high school chemistry courses leave room for just a little realistic portrayal of exactly how scientific discoveries are made? Could we not tell our students of the fact that in all human history there never has been a single important scientific invention or discovery made and then lost so far as we can construe the evidence?

How careful have we been to teach our students the impor-

tance of the scientific method? Ah! Now you can sit back and relax. The speaker has returned to well-plowed territory!

But just a minute! After you have explained all about the importance of carefully authenticated facts, general laws, hypothesis, theory, and truth, after you have explained that there is absolutely nothing dependable in human thinking except that which is based upon the reproducible experiment, then what? Have you exemplified in your daily lives the fact that a man or woman can, at least to a high degree, free himself from the tyrannies of out-worn prejudices and superstitions? Or do you vote Republican or Democratic just because your father did?

Are you a scientist as far as physics, chemistry, and mathematics are concerned and a victim of the mistaken thinking of past centuries when the social sciences are under consideration? Is your chemistry 1945 and your economics strictly Adam Smith?

Fundamentally, a great deal of the students' attitude toward science and scientists depends upon what kind of people you and I and the other science teachers happen to be. And while we are on this subject, the idea that scientists are screw-balls is easily promoted by the indiscriminate use of pictures of people such as Mendeléeff who appear never to have seen a razor or pair of scissors. I wonder if this is good strategy!

What I have been trying to say is that the public attitude in America toward science and scientists very much needs changing, and to a considerable extent these attitudes are made in the high school science classrooms and laboratories. Unfortunately, we can not change the past and American political life is now dominated by old men most of whom had little training in science and still less instruction in the methods by which scientific progress is made. Some day the youngsters whom you are teaching this fall will be among those running the nation. Will they have retained any vestige of the idea that the most powerful force for change in modern society is scientific research?

In an age when atomic bombs are capable of destroying a nation overnight will they be willing to face facts in the spirit of science? Can we, as scientists, teach the scientific attitude as an approach to all the problems of life?

These, it seems to me, are among the principal objectives in science teaching in our high schools.

AN IMPROVED SPHEROMETER

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Introduction

Attempted use of the conventional "physics laboratory" spherometer (Fig. 1) for determining the diameters of a large number of spherical fractions made of relatively soft plastic disclosed that the instrument is not well suited for either rapid or repeated measurements where high precision is desired.

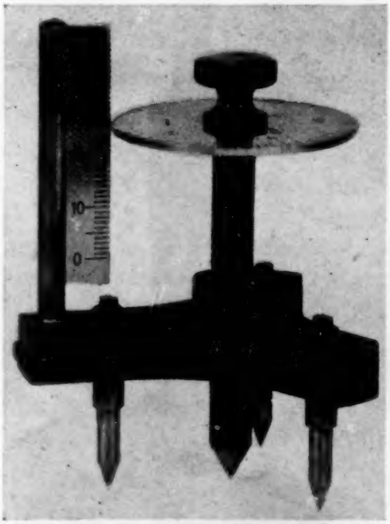

Fig. 1. A laboratory type spherometer.

Arrangement of the scales—one horizontal and one vertical—required considerable eye-shifting on the part of the operator, and led to a rather high percentage of errors. Mechanical awkwardness and lack of a definite zero point made operation slow. Spring in the legs made it difficult to repeat a measurement, and led to additional probable error. Lack of mechanical ruggedness resulted in much minor instrument damage, which, because of the three-legged design, could not be detected easily. Precision checking of the dimensions of the laboratory instrument was well-nigh impossible. In addition, the pointed legs of the conventional spherometer tend to scratch soft

surfaces, and in some instances to penetrate the surface being measured, introducing additional chances of error.

Improved Model Spherometer

Checking of the necessary requirements showed that a ring could be substituted for the three legs of the conventional spherometer; and that a standard machinist's micrometer, with which most laboratory and shop workers are familiar, could be used as the measuring element. Several instruments of this type were made; one is shown in Fig. 2.[1]

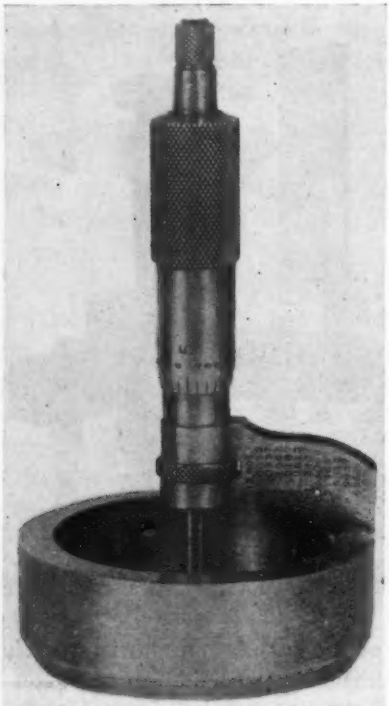

Fig. 2. Improved model spherometer.

With this modified design, only one scale is read. Zero of the instrument (plane surface indicated) is zero of the scale. Height above the zero plane is indicated directly by the mi-

[1] This instrument is designed for determining the diameters of convex spherical fractions. Measurement of concave fractions can be accomplished by use of a ring and a machinist's depth gauge properly combined.

crometer scale. Diameter and roundness of the ring can be checked rapidly by means of a standard inside micrometer. The inner corner of the ring is not likely to scratch the surface being measured; nor is it, because of the increased bearing surface, likely to penetrate it.

Use of the ratchet stop on the conventional micrometer makes it possible for even an unskilled operator to detect "contact" and to check zero. "One hand" operation of the improved spherometer is possible, although not recommended. Similar operation of the laboratory model is nearly impossible. Increased ruggedness of the improved model leads to an increase in its "life" between readjustments.

Constructional Features

Construction of a spherometer of this improved design is not difficult, and obtainable precision is high. First to be made is the ring, which should be of well-aged steel. This is finish turned to the desired size on all exterior surfaces; rough turned (about .005″ undersize) on the inside. Next a slot to fit the micrometer frame is milled in one side. The micrometer frame is cut away until it permits the spindle to occupy a vertical and central position in the ring, after which the frame is silver soldered to the ring. Centering is facilitated if a metal plug is turned to the inside diameter of the ring and drilled centrally to just clear the micrometer spindle (hole .001″ larger than the spindle diameter). This plug is inserted into the ring, and the micrometer aligned and centered with its aid before and during silver soldering. The micrometer parts are protected from heat and flux fumes by means of a liberal coating of putty.

After silver soldering is completed, and the exterior surfaces of the spherometer are cleaned and polished, the micrometer spindle is removed, the spherometer is again put in the lathe, and the interior of the ring ground to finish dimensions.

Zeroing is accomplished by setting the spindle adjustment at zero, locking the spindle, and lapping the ring and spindle to a plane. This is conveniently done on a sheet of plate glass, using fine carborundum abrasive, with light oil as a lubricant. Finish lapping can be done on a new glass surface, using jewelers rouge.

Computations

Determination of the diameter of a spherical fraction by use of a spherometer involves computation in most instances, the

construction of a direct reading spherometer being difficult and impractical.

Figure 3 represents a cross section of a spherical fraction, with the spherometer in place, and the spherometer spindle in contact with the spherical surface.

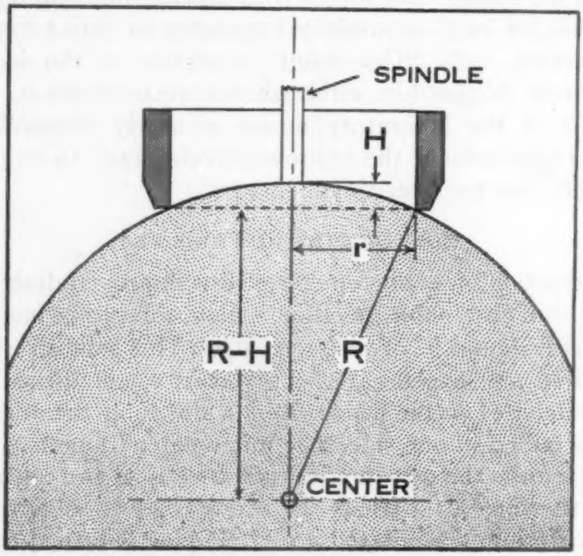

FIG. 3. Cross section during measurement by use of spherometer.

In Figure 3:

R is the radius of the sphere to be measured.

r is the radius of the spherometer ring.

H is the height of the spherometer spindle above the plane of the base of the spherometer ring. This is the scale reading of the micrometer.

In this figure:

$$R^2 = r^2 + (R-H)^2$$

$$2RH = r^2 + H^2$$

$$2R = D \text{ (Diameter of sphere)}$$

$$D = \frac{r^2+H^2}{H} = \frac{r^2}{H} + H.$$

If r is so selected that it has an even value, computations are greatly simplified, and if r is one, giving the spherometer ring

a diameter of two inches, which is mechanically convenient, the formula becomes:

$$D=\frac{1}{H}+H.$$

With this arrangement, computations are reduced to one division and one addition. The division can be eliminated by use of a table of reciprocals of the requisite number of places (three for a thousandths micrometer, four for a ten thousandths instrument). Computation errors are somewhat less if a table of reciprocals is used.

Consistency, Accuracy and Sensitivity

Commercial micrometers of the better grades are usually consistent to within about 1/20 of the smallest division when new. Use of the ratchet stop greatly reduces inconsistencies due to varying contact pressure. With reasonably good components, the major source of inconsistency with a spherometer of this type will be temperature variations. These are almost negligible when a steel part is measured with a steel micrometer, both being at the same temperature; but definitely not so when the part to be measured has a coefficient of expansion differing greatly from that of the micrometer. When the micrometer is differentially heated, very great errors may be introduced by warpage.

The accuracy of a spherometer of this type is rather hard to define. The micrometer used, if of standard commercial grade, will be accurate to about one quarter of the smallest division. The ring can be ground, using commercial shop equipment, to about .00005″ in any one diameter, but "out of round" error will probably bring the effective accuracy down to about .0005″, plus or minus. Hence, accuracy of ***direct measurement*** to within about .0005″, plus or minus is obtainable. Both absolute and proportional accuracy of the diameter, which is a derived measurement, fall off rapidly as the diameter increases, until, when the diameter of the sphere exceeds about 150 feet, it cannot be distinguished from a plane surface by means of the spherometer here described ($r=1''$).

Sensitivity, likewise, decreases as the diameter of the sphere increases. From a height reading of zero to one of .01″, the indicated diameter decreases from infinity (plane surface) to

100.01″ (the .01 is meaningless). An increase in H from .500 to .510 covers a decrease in indicated diameter from 2.5″ to 2.47″. At the upper end of the scale, an increase in H from 0.99″ to 1.00″ covers a decrease in diameter of from 2.0001″ to 2.0000″ (the .0001 is open to question in most instances).

Hence, all factors considered, a spherometer of this type can be expected to give accurate and consistent measurements to within about .0005″ when the diameter to be determined is between 2″ and 4″; with a gradual falling off in accuracy and sensitivity so that the error in the case of a ten inch diameter may be as much as .005″; complete "breakdown of discrimination" occurring when the diameter exceeds 150 feet.

The above considerations indicate that, in most cases, use of a ten thousandths micrometer head is not only supererogatory, but because of the additional time needed in reading the instrument and computing the results to an additional decimal place, extremely inefficient.

Maintenance and Service Life

Routine maintenance of a spherometer of this type consists of frequent checks of the diameter and roundness of the ring; inspection, cleaning and oiling of the micrometer head; checking of the zero (best done on a surface plate); and inspection of the inner bottom corner of the ring, to determine its condition. Relapping of the ring is indicated whenever the bottom corner is rounded, or whenever zero adjustment is "off."

Experience suggests that relapping is desirable after about 2,000 measurements, and that the effective service life of the instrument is about 20,000 measurements if carefully used.

Conclusions

Theoretical considerations and practical experience indicate that a spherometer constructed according to the general design outlined above has far greater accuracy and consistency than the conventional laboratory type. In use, the improved model requires less time per measurement, is less awkward to read, and requires less computation to derive the diameter of the spherical fraction.

It requires less character to discover the faults of others, than to tolerate them.—*J. Petit Senn.*

THE WITCH OF AGNESI*

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At one time in the history of mathematics it was quite fashionable to study curves. Loci of every conceivable form were defined and then investigated. Before the powerful tools of the calculus became available, the study of the properties of these curves often required ingenuity of a high order and presented problems worthy of the best mathematicians. The invention and development of the calculus made possible general methods of attack on these problems, whereupon the investigation of individual curves lost favor. Today we find many of these curves relegated in the textbooks to exercises illustrating bits of mathematical theory. Every student of analytic geometry and the calculus becomes more or less acquainted with several of these curves. Among them are the cissoid of Diocles, the lemniscate of Bernoulli, the conchoid of Nicomedes, the folium of Descartes, the spiral of Archimedes, and the witch of Agnesi.

The witch of Agnesi! What a strange, romantic name for a locus. Who was Agnesi? Why is this curve called the "witch"? These questions must have occurred to many of you, but our textbooks do not furnish the answers. Neither is there any clue in the rather ordinary equation of the witch,

$$y(a^2+x^2)=a^3.$$

In the following pages I shall try to answer both of these questions for you.

MARIA GAETANA AGNESI

Maria Gaetana Agnesi was born at Milan, Italy, on May 16, 1718. Her father was professor of mathematics in the University of Bologna. Maria showed a marked aptitude for languages at a very early age. By her ninth year she had mastered Latin; indeed, the child wrote an elaborate address in that language defending the propriety of her sex pursuing liberal studies. By her thirteenth year Maria had acquired Greek, Hebrew, French, Spanish, German, and other languages. As a consequence, she was generally known as the "walking polyglot."

It was the custom of Maria's father to invite the most learned

* A talk presented to the New Mexico Alpha Chapter of Kappa Mu Epsilon, Feb. 8, 1944.

men of Bologna to assemble in his house at stated intervals. As early as her fifteenth year, Maria acted as hostess for these assemblies. We may suspect that a doting father used this means to display his precocious child. At any rate, it is related that Maria read a series of papers before these gatherings on abstruse philosophical questions. The assemblies attracted visitors from all over Europe, but such was Maria's command of languages that she was able to converse in the language of each guest.

These displays were not pleasing to Maria who was of a retiring disposition. They ceased in her twentieth year and henceforth she led a secluded life. Much of her time was devoted to the study of mathematics, to the teaching of her younger brothers, and, after the death of her mother, to the management of the household.

In 1748 Maria Agnesi published the *Instituzioni Analitiche.* This work, printed in two volumes at Milan, was written partly for her own amusement and partly for the instruction of a younger brother who showed a taste for mathematics. The first volume of the *Instituzioni Analitiche* is concerned with the analysis of finite quantities; the second volume treats of the analysis of infinitesimals. The latter volume had the distinction of being one of the first publications on the infinitesimal analysis, and as late as 1803 it was considered the most complete treatment of that subject. The *Instituzioni Analitiche* was translated into French in 1775, "because of its clarity, rigor and method." Later, in 1801, the work was translated into English by John Colson and became recognized as the best introduction to the works of Euler and other mathematicians of the continent.

In 1750, Pope Benedict XIV appointed Maria Agnesi to occupy the chair of mathematics and natural philosophy at the University of Bologna during her father's illness. These duties ended two years later upon the death of her father, and Maria returned to a life of seclusion, devoting much of her time to the sick and the poor. When a new home for the aged, sick, and poor was opened in 1771, Maria took charge of visiting and directing the women and was "an angel of consolation to the sick and dying women until her death at the age of 81 years on January 9, 1799."

In 1899 Italy celebrated the one hundredth anniversary of her death by appropriate ceremonies. In her honor, a cornerstone

was laid having the following inscription

Maria Gaetana Agnesi
erudite in mathematics
glory of Italy and of her century
most acknowledged in asylum of poor and old
humble servant of charity
died in the year 1799.

History of the Witch

Let us now consider the history of the curve which bears the name of this admirable woman. Fermat (1601–63) studied the quadrature of various curves, discussing among others the curve whose equation he wrote in the form,

$$e(a^2+b^2)=b^3.$$

If we replace e by y, a by x, and b by a, we obtain the modern form,

$$y(x^2+a^2)=a^3,$$

which is precisely the equation of the witch. This seems to be the earliest reference to this curve. Fermat showed that, if we make the substitutions,

$$y=u^2/a, \qquad x=av/u,$$

then the equation of the witch takes the form,

$$u^2+v^2=a^2.$$

Thus, Fermat showed that the quadrature of the witch could be reduced to the quadrature of a circle.

Guido Grandi (1672–1742), an Italian mathematician, discussed the same curve in his *Quadratura circuli et hyperbolae.* Grandi gave the name *vesoria* to the curve. It is not clear just what Grandi had in mind in naming the curve thus. In Latin *vesoria* is a rope that guides a sail. Perhaps the witch suggested such a rope to Grandi.

Neither the work of Fermat nor Grandi attracted much interest to the witch. The attention of mathematicians was drawn to the curve by its appearance in the *Instituzioni Analitiche* of Maria Agnesi, and thereafter it was referred to as the "witch of Agnesi."

Apparently, Maria Agnesi was familiar with the *vesoria* of

Grandi and intended to use the same name in referring to the curve. It is believed that she confused *vesoria* with *versiera*, the name given by her to the curve. In Italian *versiera* means the devil's grandmother, a female fiend or goblin, a bugaboo to frighten little children, etc. The word *witch* is John Colson's translation of Agnesi's *versiera*.

Properties of the Witch

This account of the witch of Agnesi would not be complete without a brief discussion of some of its properties. The witch is defined as the locus of points P obtained in the following manner (Fig. 1): Let $OA=a$ be the diameter of a circle with center at the point $(0, \frac{1}{2}a)$, and let AT be the tangent at A. Draw line OT intersecting the circle at C and the tangent at T. Draw CP parallel to the x-axis and PT parallel to the y-axis Then P is a point of the witch.

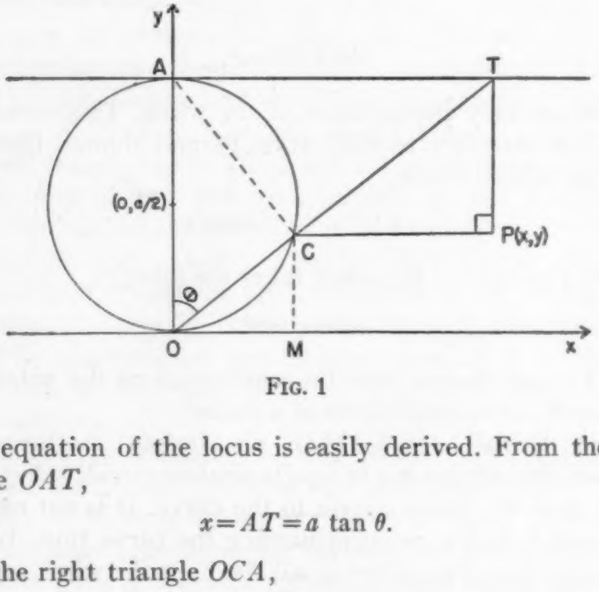

Fig. 1

The equation of the locus is easily derived. From the right triangle OAT,

$$x=AT=a \tan \theta.$$

From the right triangle OCA,

$$OC=a \cos \theta.$$

Then

$$y=MC=OC \cos \theta=a \cos^2 \theta.$$

Thus, the parametric equations of the witch are

$$x=a \tan \theta, \quad y=a \cos^2 \theta.$$

To eliminate the parameter, use is made of the identity,

$$1+\tan^2\theta=\sec^2\theta.$$

We find

$$1+\tan^2\theta=1+x^2/a^2=(a^2+x^2)/a^2;$$
$$\sec^2\theta=a/y.$$

Therefore,

$$(a^2+x^2)/a^2=a/y,$$

or

$$y(a^2+x^2)=a^3.$$

The following properties of the witch may be noted from a study of its equation:

(1) There are no x-intercepts;
(2) The y-intercept is equal to a;
(3) There is symmetry about the y-axis;
(4) y cannot be negative;
(5) There is one asymptote, $y=0$;
(6) There is a maximum point at $(0, a)$;
(7) There are points of inflection at $(\pm a/\sqrt{3}, \frac{3}{4}a)$.

The curve is drawn in Figure 2.

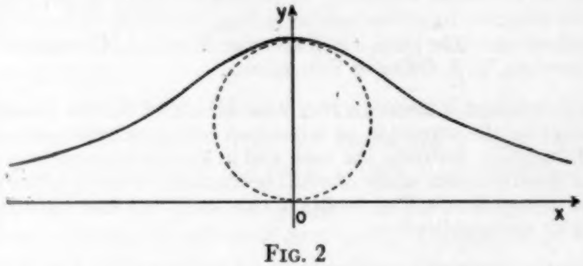

FIG. 2

Further properties of the witch may be of interest. At first sight, properties 11 and 12 appear paradoxical. Why does one volume become infinite and the other approach a limit?

(8) The area comprised between the curve and its asymptote is equal to πa^2, which is just four times the area of the generating circle;

(9) The centroid of the area bounded by the curve and its asymptote is $\bar{x}=0$, $\bar{y}=\frac{1}{4}a$;

(10) The largest rectangle which can be drawn with its base

on the x-axis and two vertices on the witch has a base $2a$ and an altitude $\frac{1}{2}a$, or an area of a^2;

(11) The volume generated by revolving the witch about the y-axis is meaningless;

(12) The volume generated by revolving the witch about the x-axis is $\frac{1}{2}\pi^2a^3$, or just double the volume of the torus formed by revolving the generating circle about the x-axis.

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THE PLACE OF VISITING TEACHER IN SCHOOL PROGRAM

The work of the visiting teacher in city school systems, and its significance in the complete development of the whole child, is the theme of a new publication announced today by the U. S. Office in Education, Federal Security Agency.

The Place of Visiting Teacher Services in the School. Program, Bulletin 1945, No. 6, is a 46-page presentation of a phase of pupil personnel work which has had a Topsy-like growth without adequate safeguards as to its placement in the school structure, as to qualifications of the officials performing the assigned functions and as to legal certification based on acceptable qualifications. The author is Katherine M. Cook, Consultant in Educational Services, U. S. Office of Education.

Recently renewed interest in this area of school service brought these shortcomings to the attention of interested school officials, and the U. S. Office of Education, realizing the need and in answer to numerous requests, initiated a questionnaire study of visiting teacher service in cities of 10,000 and above in population. The results of this study are summarized and discussed in this new publication.

The bulletin contains four chapters and an appendix. Chapter I is devoted to a discussion of the growing importance of pupil personnel services in the schools; Chapter II tells of the development of visiting teacher (school social worker) services; Chapter III describes the present status of such services in cities; and Chapter IV is concerned with the extending and improving of visiting teacher services. The appendix contains the questionnaire used in obtaining data on which the study is based, several tables, and examples of State certification of visiting teachers.

Copies of Bulletin 1945, No. 6, *The Place of Visiting Teacher Services in the School Program*, may be obtained by purchase, at 10 cents each, from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

RELATIVITY IN GENERAL PHYSICS

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The theory of relativity may be considered one of the most contraversial of modern physical theories. This is due largely to the unfortunate publicity given certain aspects of the theory, and to the wide misinterpretations of some of its conclusions. This is unavoidable because these results cannot be stated in our every-day language without being misunderstood. Another outgrowth of this dilemma is the familiar phraseology that only Albert Einstein and six—or ten—or a hundred men in the world understand relativity. It is granted that some of the mathematical aspects of the theory present some difficulty, but the average college freshman can easily understand the fundamental postulates and some of the startling results.

In a survey of textbooks of physics written during the past fifty years, an attempt has been made to trace the introduction of the theory of relativity into student literature. Since Einstein's announcement in 1905 was based on the preliminary experiments of Michelson and Morley, performed as early as 1881, some of the older texts were examined to see whether this experiment was included. The texts were chosen at random. No attempt was made to include all of the possible publications during the period. The results merely represent a cross section of published texts.

A total of one hundred and nineteen texts and source books were studied. Of these, only two elementary texts contained an adequate discussion of the basic principles of relativity. Four intermediate or advanced texts gave satisfactory treatments. Five others presented shorter accounts. Twenty-four devoted one paragraph to a mention of some phase of relativity. Thirteen others used the word in a brief sentence or two. Nine texts discussed the Michelson-Morley experiment. Sixty-two texts contained no mention of relativity at all.

To interpret these results the fundamental objectives of science teaching must be considered. In professional circles education is regarded as a growth, expressible in terms of abilities, attitudes, habits and interests of students. These aims may be developed through proper use of the scientific method. Our students should be encouraged to base their judgements on

facts rather than opinions. They should be aroused to discover new truths, to prepare new products, to identify new things. Not only should the student of science appreciate materials and processes, but he must possess a willingness to change his beliefs should new evidence warrant this.

Unfortunately the teaching of physics has been static for many years. From the secondary school viewpoint physics has been regarded chiefly as a college preparatory subject. In our colleges and universities it is largely a tool subject, a prerequisite for medicine or engineering. Not many of our elementary courses or textbooks substantiate the statement that physics "reveals and interprets life, giving breadth, perspective and balanced appreciations."

Physics, as a pure science, is composed of a mass of facts, principles, ideals and methods. A large portion of these have great transfer value, by which training may be carried over from one field to another. The values gained from a general physics course are due in part to the organization of the course and in part to the instructor. Professors, rather than subject matter, often determine the selection of college courses. The professor should awaken new interests and stimulate the student to think. If he will "sell" subject matter by arousing curiosity, or by making the student see the need for such material, any professor will be able to "put over" the most difficult topics. Proper motivation will insure maximum transfer values. It will also overcome the usual dread of the physics building. This, incidentally, may be an important factor in increasing the size of the intermediate and advanced courses.

The textbooks of elementary physics offered for college or secondary school students are nearly all written from the classical viewpoint. There is a fixed arrangement of topics, which surveys of the interests of students tell us are outmoded. The concepts of physics are not developed psychologically. The texts fail to develop the ability to use science and scientific ideas as a method of thinking. Most of the texts present mathematical difficulties which prevent proper use of the book by most of the students.

A satisfactory text should be a motivating factor, not simply an arrangement of facts. All concepts of physics should be developed completely and carefully. The texts must, of necessity, be somewhat difficult to read. They should be read with a pencil and paper, even by the beginner. This means that the

average college freshman must be taught to concentrate, to "dig out" a certain amount of material. The remainder must be interpreted for him by the careful instructor, with proper motivation.

With these facts in mind, how does the theory of relativity fit into an elementary physics course? The results of the survey cited above seem to require justification for the inclusion of relativity in such a course. Applying the tests for desirable teaching material to the theory of relativity, we find that:

(1). Relativity may be presented simply and logically, without use of higher mathematics. An adequate summary of the postulates of the theory may be given using college algebra and trigonometry. This does not mean that in advanced courses the rigorous tensor analysis treatment should be abandoned. The discussion here is concerned with the basic (freshman) general physics course.

(2). Relativity does appeal to student interest. This is true because of the mysticism and publicity associated with it. The recent references to relativity in the press and news magazines in connection with the atomic bomb illustrate this.

(3). It satisfies a real need by presenting a new idea with far-reaching significance to the student in a basic course. Too many of our physicists teaching the elementary classes believe strongly that only the classical concepts should be included. The average student prefers modern physical ideas to the classical, particularly if the classical are without familiar application. To adhere to the classical is contrary to the aims of education.

(4). Relativity is a contraversial topic. This means that a skillful handling of the topic will stimulate thinking. Is not intellectual independence one of the great goals of teaching?

The apparent neglect of relativity may be defended on the grounds that the work is too abstract and too difficult for the average student of elementary physics. Further, there are those who believe that a theory should not be presented to students, particularly in an introductory course, until it has been universally accepted. This means until all possible questions concerning it may be answered satisfactorily. This is in direct contradiction of one of the fundamental laws of science—that science is continually changing—that no individual can ever hope to know the last word about any theory.

Another defense of the exclusion of relativity is the time element. Professors complain that there is not enough time in

the semester to stress the classical principles which are the foundation of the advanced courses. Remembering that a large percentage of the basic students will never pursue an advanced course, is it not desirable that the interests of these students be maintained throughout the course? A wider range of subjects discussed is one answer. From personal experience the students prefer a broad, semi-survey course, including such topics as relativity, rather than the old-fashioned, rigid, problem-solving course.

A few remarks on the method of presentation of relativity may be in order. The work may follow mechanics, or come as a part of a survey of modern developments in physics toward the end of the second semester of the general course. Since Newtonian relativity may be regarded as an extension of the Galilean principle of relativity, the theory may be introduced as a consequence of motion, directing attention to the impossibility of detecting motion with respect to an inertial system by mechanical experiments. This leads directly to the distinction between special relativity and general relativity. It should be pointed out that the complete general theory is too complicated to attempt to introduce in an elementary course, thus restricting discussion to the special theory. The next step should be the concept of space-time continuum. Familiar examples, such as rapidly moving clocks and trains, clocks on airplane rides or watches on airplane pilots, serve to arouse interest in the presentation of these ideas. The principle of synchronization may now be defined.

There are some who believe that the discussion of the theory should begin with the Michelson-Morley experiment. If the presentation follows optics and interferometry, this is a logical starting point. Whether the experiment should be the introductory topic, or inserted at some other point, is immaterial. A clear, adequate discussion is certainly a part of an introduction to relativity.

The Lorentz transformations should be derived. This may be done on the basis of the Michelson-Morley experiment, using the contraction value obtained, or independent of this experiment.

Composition of velocities results from application of the Lorentz equations. Likewise equations for mass, momentum, force and energy may be set up using the transformations. The mass-energy concept is likely to be the most familiar of these,

and undoubtedly is the one with the widest application. It is easy to show that this new idea is related to classical kinetic energy. The practical applications resulting from this equation alone make its inclusion worth-while. Applications should be stressed whenever possible.

For the average college freshman class, three to five hours for such a presentation is sufficient. This is not excessive in view of the far-reaching importance of the subject. It may be regarded by some as inadequate, but here again the time element for the entire course must be considered. The skillful professor will find it advisable to deviate from a fixed outline of presentation of relativistic ideas. The reaction of the group will determine this. The instructor should guard against progressing too deeply into the subject without adequate rigorous justification for the statements made. His own, and his class' enthusiasm should be checked by common sense.

Thus, in this atomic age, the content of our standard elementary physics courses should be surveyed critically. Those topics beneficial to the development of our educational aims should be included. Others should be revaluated in the light of our modern times. Like Bacon, we should realize that

"Books must follow sciences, and not sciences books."

TRANSOCEANIC FLYING CONDUCTED WITH FLIGHT FAILURES APPROACHING ZERO

Transoceaninc flying has not advanced to the point where commercial operations may be conducted with flight failures approaching zero, declared Frank R. Canney of Boeing Aircraft Company here today at the national air transport engineering meeting of the Society of Automotive Engineers. He estimated the probable frequency of emergency landings, or "ditchings," on the New York-London flight currently as about one in 16,576 flights.

Mr. Canney cited wartime flying records to prove his point. He reported that total AAF B-29 operations during the war, including combat flying, resulted in only one "ditching" for each 750,000 miles flown.

Increased cruising speeds, improved engine performance, and the operating policy of adopting alternate flight plane whenever trouble begins to develop, make the chances of emergency landings low. Transoceanic flying safety is enhanced by use of weatherproofed aircraft equipped with pressured cabins, four supercharged engines, and radio communication.

Flying altitudes of 15,000 to 35,000 feet, he added, enable planes to take advantage of the most favorable winds. Flying speeds of 200 to 400 miles an hour make crossings so brief as to minimize chances of mechanical failures. Engineering requirements for overwater flying differ little, Mr. Canney stated, from those of overland routes.

MICROTECHNIQUES FOR PROJECTION DEMONSTRATIONS IN GENERAL SCIENCE

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Those aware of the potentialities of science, of the economic consequences of scientific achievement, of the value of the scientific method, realize the necessity for teachers of science to work ceaselessly to improve their teaching using new ideas and methods. In this way teachers may find the proper topics of science to teach and the most advantageous way of presenting them.

Science is distinguished from other subjects commonly studied by its use of experiments in investigations. It is obvious therefore that the performance of experiments plays a major role in the teaching of any scientific subject. When an experiment is performed by or for the student, the student in a simplified way "discovers" the principle involved in much the same manner as the original formulator of the principle discovered it. In effect the student is following the steps which led to the statement of the principle. In other words he is using the scientific method. Furthermore there is nothing more stimulating in the science lesson than a well planned, well performed experiment. It makes the student think, invites discussion, and prompts him to suggest the next step in the investigation.

The experiments may either be performed by the students or demonstrated by the teacher for them during the science period. Each method has its advocates but the present paper is concerned only with the latter.

Let us examine the requirements of a successful demonstration experiment. The ideal demonstration experiment according to Wendt[1] "Should be investigative, should furnish definite and convincing facts for the mind of the student, and should be variable to meet the needs of the argument and the inevitable questions from the intelligent students. So conducted they do accord with the scientific method and constitute the most valuable portion of a course." While there can be no dispute with this statement the average teacher of general science in the

[1] Wendt, G.: *Journal Chemical Education*, 8: 278, 1931.

high school is unable to include as many of these experiments as may be desired because of limitations of time, equipment, and funds. Furthermore, elaborate experiments place a tremendous strain upon the teacher who has no assistant. Aside from the task of preparing the experiment, it is performed before a critical, expectant, and possibly exuberant class which is prepared equally to profit by the teacher's success or enjoy his failure. In addition to performing the demonstration the teacher must simultaneously keep order, maintain interest, and last but not least—teach.

In spite of these disadvantages such elaborate experiments are highly desirable and every effort should be made to overcome these disadvantages. One method of attack is to employ projection equipment. The chief value of projection equipment lies in the increased visibility of the experiment and also makes it possible to eliminate time consuming procedures such as the passing around of test tubes so that students may observe the result of an experiment. A demonstration loses all value if it cannot be seen. No one can successfully note results or draw inferences from a demonstration if he cannot see it in its entirety. It is also true that projection equipment is interest-provoking to a student entering a science classroom. He immediately becomes mentally alert as he endeavors to discover before his fellow classmates, what the teacher is going to do that period. "Although the showman spirit—assuming the term to connote the flash and bang for their own sake—should be suppressed, yet the experiments should be made as spectacular as possible."[3]

This is expecially true for the 9th year students. However university students as well as school children enjoy the thrill of seeing on the screen a change in color, increase in size, or the effect of an explosion. As Rakestraw says: "A sense of the dramatic is essential to the success in the art of lecture demonstration."

Projection experiments have already been suggested for use in advanced science courses. Richards suggests the use of the Spencer Model "B" Delineascope for the projection of chemical lecture experiments on the screen. Sargent suggests that the microprojector he used for demonstrations in advanced physics and chemistry courses. The author has found that the microprojector can be used for demonstrations in a general science

[3] Fowles: *Lecture Experiments in Chemistry*, Philadelphia, P. Blakiston's Sons Co., Inc., p. 9, 1937.

class. This may be done very successfully using a minimum of effort, time, and materials.

The principles of the experiments suggested in the general science text books on the macro scale can be more successfully and convincingly demonstrated by the use of the microprojector The reactions performed on the micro scale use minute quantities of materials, require little equipment, and are speedy. This attains an important goal of teachers in the demonstration of science principles, namely—simplicity of equipment and technique. Although it may require a short time for a teacher to gain the manipulative skill required for successful demonstrations using the microprojector, once he has gained mastery of it he will find it an invaluable teaching aid.

Realizing the hardships of the average general high school teacher the author has devised a number of representative demonstration experiments using microtechniques to show the practicability of these methods. This does not imply that just *these* experiments are recommended for inclusion in a general science course. The author used as a general guide the science principles suggested for demonstration in the Beauchamp, Mayfield, and West "Everday Problems in Science."

The only equipment needed for such projection demonstrations would be the microprojector, and a screen. Several capillary tubes would also be required for the transfer of liquids to or from the microscope slides. These may be prepared very easily. Capillary tubes should be drawn from soft glass tubing of about 6 to 8 mm. diameter. Grasp a piece of such tubing at both ends and while rotating the tubing around its axis, heat in a Bunsen flame so that a length of from 1 to 3 cm. becomes soft and workable. Then remove from the flame and draw the cool ends apart, easily at first and then more strongly as the glass cools. Since the rate of drawing determines the bore and the length of the capillary obtained, practice will be necessary until the size capillary desired is obtained. The final capillary should have a bore of about 1 mm.

The author has worked out the microtechniques for the projection of the following experiments:

Demonstration to show that solids expand when heated

Materials:—

1. Six inch piece of copper wire or an ordinary large safety pin straightened out.
2. Ring stand.
3. Clamp.

4. Microprojector.
5. Bunsen Burner.

Method:—

Set up microprojector. Place copper wire or straightened pin in clamp and attach to ring stand. Start arc lamp and arrange wire or pin above the stage of the microscope so that the tip of the wire or pin is shown in the field projected on the screen. Do not allow the wire to rest on the stage of the microscope. Heat other end of wire or pin with Bunsen burner until the expansion is visible on the screen.

Observation:—

End of wire moves rapidly across the projected field and increases in diameter as the wire expands from the heat.

Demonstration to show that solids do not dissolve in all liquids

Materials:—

1. Microprojector.
2. Resin (extremely tiny pieces).
3. 1 ml. alcohol.
4. 1 ml. water.
5. Capillary.
6. Microscope slide.

Method:—

Prepare several capillaries as described previously.

Place clean slide on the stage of the microscope. Dip capillary into water and then put a small drop on the microscope slide. (The water will enter the capillary by capillary action. To get the water from the capillary to the slide blow gently through the capillary, being careful not to get too large a drop.) Place a tiny piece of resin in the drop of water. The piece of resin used should be no larger than the head of a straight pin. Observe that nothing happens. Focus carefully.

Remove the water from the slide by means of the capillary or use a triangle of filter paper to absorb it.

When the water has been removed, add a drop of alcohol from the capillary (using the same procedure as for the water). Observe now that the same piece of resin begins to dissolve and soon completely disappears. The demonstrator must be careful to add enough alcohol to completely dissolve the resin, otherwise the alcohol will evaporate rapidly and the action will stop. By using the same piece of resin in both the water and then the alcohol the student will readily see that solids do not dissolve in all solvents.

This general procedure may be used in similar demonstrations using other solids and solvents.

Demonstration to show that heating hastens evaporation

Materials:—

1. Microprojector.
2. Microscope slide.
3. Concentrated solution of potassium permanganate.
4. Capillary.
5. Two test tubes, one must be Pyrex.

Method:—

Prepare several capillaries.

Prepare a concentrated solution of potassium permanganate. Pour some in each of two test tubes. Heat one of these test tubes (Pyrex) on a water

bath or over a free flame. On a slide place a small drop of the cold solution. (Do this by using the capillary. The solution will enter the capillary by capillary action. To get the solution from the capillary blow gently into the capillary.) Right next to the drop of cold solution place a drop of hot solution using the same method. Focus so that the edges of both drops can be seen on the screen in the same field. Observe the evaporation until the drop of the hot solution shows crystal formation due to the evaporation of the water. The cold solution will still be clear.

Be sure to put the drop of cold solution on the slide first. The slide is being warmed by the heat from the arc lamp. This will prove more conclusively that the heated solution evaporated faster.

Demonstration to show how chemical change may be prevented

Materials:—

1. Several small pieces of iron wire about .010 of an inch in diameter.
2. Microprojector.
3. Microscope slide.
4. Capillary.
5. Dilute sulphuric acid.
6. Vaseline or heavy oil.

Method:—

Prepare several capillaries as previously described.

Place the microscope slide on the stage of the microscope. Place a small drop of dilute sulphuric acid on a slide by means of a capillary. (The solution will enter the capillary by capillary action. Blow gently into the capillary to get the acid on the slide.)

Scrape two small pieces of iron wire clean of all dust or oil acquired through handling. Grasping the wire at one end only by fingers or forceps, carefully place it on the slide so that one end is in the acid. Bubbles of hydrogen will soon appear around the wire as chemical change occurs. Focus carefully. Take the second piece of wire, also scraped clean, dip in heavy oil or vaseline, and carefully place it on the slide so that one end is in the acid. Place it near enough to the first wire so that both are visible in the projected field at the same time. Observe that no bubbles appear around the second wire coated with the oil or vaseline. In this case the oil or vaseline has prevented chemical change.

Demonstration to show what happens when a chemical change occurs

Materials:—

1. Microprojector.
2. Microscope slide.
3. Cover slip.
4. Citric acid crystals.
5. Sodium bicarbonate.
6. Capillary.

Method:—

Prepare several capillaries.

Place a pinch of sodium bicarbonate on a slide. Add several grains of citric acid crystals. Mix together. Observe that no reaction takes place. (If the weather is humid a slight reaction may occur due to the moisture in the air. To prevent this, dry the citric acid crystals before using.)

Now place cover slip over the crystals and add a drop of water at the edge of the cover slip by means of the capillary. (The cover slip will prevent splattering on the lens during the reaction.) Then, as a fairly violent

reaction occurs, the carbon dioxide bubbles formed may be observed moving about erratically on the screen. The characteristics of the remaining solution are entirely different than the crystals started with for their individual identity is now lost. A chemical change has occurred.

Using the micro method cuts down greatly on the number of test tubes, beakers, and flasks used. The necessary yearly replacements of these due to breakage is greatly reduced. The micro method uses less material.

The author does not intend that these micro methods be used in place of the macro methods of demonstration, but rather that they be used to supplement them. There is no doubt that in cases where micro methods may be used they leave a more vivid impression of the principle demonstrated. Projection demonstrations are definitely a visual aid, and for a student "Seeing is Believing."

A NEW TELEVISION CAMERA TUBE

A new television camera tube of revolutionary design and sensitivity emerged from wartime secrecy for exhibition by the Radio Corporation of America in a series of studio and remote pickups in which it not only transmitted scenes illuminated by candle and match light but performed the amazing feat of picking up scenes with infra-red rays in a blacked-out room.

The new tube, known as the RCA Image Orthicon, was demonstrated to newspaper and magazine writers in a studio of the National Broadcasting Company, Radio City, with the cooperation of NBC's engineering and production staff. In the exhibition, members of the audience saw themselves televised under lighting conditions that convincingly proved the super sensitivity of the new electronic "eye" which solves many of the major difficulties of illumination in television programming and makes possible 'round-the-clock television coverage of news and special events.

Further evidence of the tube's superiority came in the transmission of scenes from a special rodeo show arranged at Madison Square Garden for the visiting United States Navy Fleet. Exciting cowboy acts were picked up by the Image Orthicon and transmitted to the studio in a comparative demonstration showing its advantage over conventional television pickup tubes in providing greater depth of perception and clearer views under shifting light conditions.

RCA-NBC engineers capped the demonstration by blacking out the studio where the writers were assembled, and providing the unprecedented spectacle of picking up television scenes in apparent darkness. Unseen infra-red (black) lights were turned on, but it was so dark that a member of the audience could not see the person next to him. Then on the screens of television receivers in the studio appeared bright images of a dancer and other persons who were in the room. The Image Orthicon tube, it was explained, achieved the feat through its sensitivity to the infra-red rays.

EXPERIMENT OR ARGUMENT?

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The late William Lyon Phelps of Yale often said that every time he gave an address he really made three; the one which he prepared, the one which he actually gave (quite different from the one he prepared) and a third, much better than either, which he made on the way home.

My own plight is even worse. On these rare occasions when I am invited to speak to a really worthwhile audience, other than my classes, I usually prepare two or three different talks. This is no exception. During the summer months, I prepared with considerable care some material which interested me very much. I even had lantern slides made. Returning to my laboratory in September I found on my desk, as many of you did, the report of the Harvard Committee on General Education in a Free Society. That started a wholly different train of thought. I put the manuscript and the lantern slides in what I may honestly call my "hope chest" and decided merely to raise with you a number of questions which really boil down to one question.

Is this not the time and is this not the place to apply to this problem of what to teach in the field of science, the method which is most characteristic of modern science, namely the controlled experiment?

First, though, as to the Harvard report. We should all be grateful for it. It proves again that important educational problems can be discussed without prolixity and without the use of educationist jargon. At times its beautiful prose arises to the level of poetry. Witness these two wholly unrelated sentences.

"Then, there was the world of crops, animals, and wild nature, the green or snowy margin ever at the door, a standing lure to learning and doing."

"The record of such people over history—the simple-hearted, those who have done the unobserved work of the world—is certainly at least as good as that of their more gifted—and more tempted—brethren."

What do the makers of this report have to say regarding the sciences? The following direct quotations are given in the order in which the statements appear in the text. They are, I believe, fairly representative of this whole section.

(Page 151) "It is this constant appeal to things as they are which makes the direct experience of the field and laboratory essential in scientific education."

(Page 153) "Mathematics and work in the laboratory represent genuine

intellectual barriers for some students. It might be supposed for this reason that the values of science instruction which are our primary concern in general education might be conveyed more successfully without these elements. What this notion fails to appreciate, however, is that direct observation and precision are among the most important values and basic ideas that science should contribute to general education.

"What might be conveyed without them is not only not science, but is in a very real sense antiscientific."

* * * *

"The thought that an understanding of science might be conveyed as well or better without direct observation, experiment, and mathematical reasoning involves a fundamental misapprehension of the nature of science."

* * * *

"Despite their many interconnections and similarities, the individual sciences differ widely. These differences emanate from the nature of physical reality; they are not simply foisted upon us by the predilections of scientists."

(Page 154) "What we deal with, therefore, in the division of the natural sciences is inherent in the modes in which the natural world appears to our senses. It is no mere traditional educational tactic. Since this is so, it cannot be exorcised by any mere educational reconstruction."

This then is the groundwork of common understanding and agreement on which the Harvard Committee bases its specific recommendations for science in the schools. The temptation to quote these recommendations and to discuss them is almost irresistible. And I know as well as you that the nicest thing about temptation is yielding to it. The point I wish to make, however, is that, with one possible exception, each of the suggestions has already been the subject of long discussion. On the other hand, so far as I can learn, not one of them has been subjected to real experimental test in a high school!

The exception noted above is the suggestion that two years of integrated physical sciences should be better than a year of physics and a year of chemistry. But why discuss even this? It must be capable of experimental test. Why should not some of our larger high schools set up parallel courses and attempt to find out which is actually better for the student? For that matter why not test *experimentally* the probably much simpler problem of the relative usefulness of a year of what is called biology as compared with a half year of botany followed by a half year of zoology? So far as I can learn this has never been done. There have been endless discussions, questionnaires, and reports. In each particular school the matter has been settled apparently on the basis of which side made the most noise.

Recently an experienced and successful teacher of botany

admitted in print[1] that after some years of trying to use short cuts in laboratory teaching he now finds himself: "tending to revert to the old style requirement of making drawings, because they give longer exposure and opportunity to raise questions which cause students to begin to think and to consider what they are seeing."

Why should such a matter be left to trial and error and debate? Why not test various laboratory methods by serious, controlled experiments?

Why indeed is experimentation almost wholly absent from our teaching of science? Why is it that when we come to problems of teaching we cease to be scientific and become argumentative? Even the careful and elaborate reorganization of undergraduate teaching at the University of Chicago seems to have had none of the kind of experimentation that I have in mind.

Some years ago when we were considering the organization of survey courses at the University of Illinois, the faculty of which I am glad to be a member honored itself by inviting Professor Carlson down to tell about his experiences at Chicago. During the question period somebody asked whether Chicago's new beginning science courses were better than the old. Professor Carlson's answer, which I quote from notes made at that time, was as follows:

"Who shall say? We changed the system and improved the instruction 300%. Who is going to say which is to get the credit?"

I quote Professor Carlson, of course, subject to correction. I am glad that he is here and can speak for himself. If his behavior at the Chaos Club is any criterion he will certainly do so.

Experimentation presents difficulties of course, but I honestly believe there is no use in more talk. Everything must have been said on all sides. Moreover there is no evidence that more talk will lead to an agreement. The effect seems to be quite the opposite. For the past three years I have been a member of our division of the National Research Council. Most of the work of the division is done through committees. During these active years only one committee has broken up through discord and had to be terminated. That was the one appointed to consider the teaching of science. At this point I am tempted to quote from a paper on the diseases of cultivated plants published in 1837.

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[1] Stevens, O. A. What is education and what is dispensable? Science 102: 457–458, 1945.

"Where there is much difference of opinion there is little real knowledge."

I am not too sanguine either about making much more progress through mere observation. Separately but at intervals of only a few years two of the younger members of our department visited the department of Botany of the Ohio State University for the express purpose of studying their teaching methods. The written reports which they submitted on returning were so diverse that it was difficult to believe that they had visited the same institution until the fact was checked by their expense accounts in the business office.

As an illustration of the kind of experiment which could be and I believe should be more generally made, I should like to quote part of a letter recently received from Dr. Glenn C. Couch of the University of Oklahoma.

"After I had been at Ohio State University and had observed their general botany courses there, I asked the Department of Botany here to allow me to carry one section of general botany in the manner that it is taught at Ohio State. It was agreed that I should do this while the staff sat in on each class and observed the general method. Four or five regular sections in general botany, of course, were carried on at the same time.

"By the time the semester was half over, the entire staff who had been observing the general botany which I was teaching, began to make plans for their own sections the second semester. However, it was decided that we had better not jump into the pond quite so quickly so the second semester we had three sections of the Ohio State method and kept the rest of our students in the usual lecture and laboratory procedure. By the time the second semester had finished, all of us were convinced that it would be a wise thing for us to completely change over to the Ohio State method of teaching.

"During that school year, we occasionally switched examinations in the two types of classes and compared results. We not only found the Ohio State students doing better but also that they were covering more material than we found possible to cover in the lecture and laboratory method. This surprised all of us somewhat since the lecture and laboratory method used seven hours per week for instruction and the Ohio State method used only five hours."

Naturally all this test proves is that under these particular conditions one method was judged better than the other by all the observers. It would be interesting to have the results of a similar test in other places. It speaks volumes for the staff of the Department of Botany at the University of Oklahoma that they could carry out such an experiment and abide by the results. Among other things it indicates, I fear, that they are all young men.

What then are the obstacles to genuine experimentation in course content and teaching methods? Of course they will cost

something. The experiments will have to be paid for and should be paid for. Make no mistake about that. They cannot be loaded on already busy teachers as extra work. On page 90 of the last volume of F. D. Curtis' "Third Digest of Investigations in the Teaching of Science" you will find what happens when anybody tries to get an experiment conducted in this way.

However, the cost in money of such experimentation would be relatively small and that would be cheerfully borne. Kettering and others have convinced the public that 99% of all scientific experiments are doomed to fail, and that the successful 1% more than pay for all the rest.

The real difficulties will be personal ones. First of all the fact that an experiment is being conducted will have to be concealed from the students. Whatever they may think of themselves, the American high school and college student seems to me the most conservative of animals (possible exceptions being pigs and mules). Speaking as an outsider, I feel that one of the great difficulties encountered by the experimental college of Wisconsin was the fact that it was known to be an experiment and its students were called "guinea pigs" on the campus.

Then we must be sure that we have teachers who understand and can stand experimentation. The conviction has been forced upon me that if experiments in course content and teaching methods are to be made seriously, they must be undertaken by such groups as that here represented. We cannot reasonably expect much help in studies of this sort from our colleagues in fields other than science. Apparently outside of the experimental sciences few have any concept of the headaches and the heartaches involved. Only those who have seen their own pet theories buried under cold facts have developed the fortitude necessary to undertake experimentation.

This conviction is the result of my experiences during the past five years. In 1940 our college of Liberal Arts and Sciences undertook an experiment in general education. That it was an experiment was clearly indicated throughout the discussions and in the formal statements. The undertaking was hardly launched when I discovered, to my amazement, that some of my colleagues were much worried lest it might fail. Of course it might fail. Many more experiments fail than succeed. Kettering as you know puts the percentage of failures at 99. Anyone undertaking experiments must be prepared to face failure. No disgrace is involved. Anyone who starts an experiment and asks

for a guarantee of success is in a class with the New England deacon who believed that gambling was wicked; so only bet on sure things.

The first objective judgment on our attempt at Illinois was based almost wholly on registration and student interest. It came from a commission of the American Council of Education which was published in 1943, and read in part as follows: "Obviously, the enrollment in the General Division of the College of Liberal Arts and Sciences forms an insignificant part of its almost 4,000 undergraduate students, and it shows no tendency to increase."

Following the publication of this report, although I am not sure how closely the two events were connected since I was on sabbatical leave at the time, the faculty on which the final responsibility rested upset the entire experimental apple-cart by voting to apply different and somewhat lighter graduation requirements to students in the General Division. Only two years later, that is, last spring, the same faculty by an almost unanimous vote reversed this decision and restored the original graduation requirements.

I do not wish to be understood as suggesting that all students of the life sciences are capable of understanding experiments in teaching or that they would be even slightly interested. There are wide differences even among followers of the botanical disciplines. A few years ago in a study of teachers of the plant sciences, I had in hand "scores" of over 700 teachers of botany. To my surprise the various groups differed widely in the grades received on the characteristic "Liberal and Progressive Attitude." The ratings received by certain groups were decidedly low. Without laboring the point it may be stated that there seemed to be a direct correlation between their fields of investigation and their scores on the characteristic mentioned. In general groups accustomed to experimentation graded much higher than the others. There are apparently a good many botanists who are neither interested in nor understand experimentation.

Obviously we cannot expect help from botanists of this stripe. A good preparation for experiments in teaching would be ten years of field work. Spending a summer arranging spraying experiments in Florida only to have a land boom come along and destroy half the trees will help. As will having a year's inoculations and measurements wiped out by forest fire. Better yet would be three or four years attempted heat treatments to free

diseased plants from a virus. The treatments are made in the late fall, the surviving plants are grown in a greenhouse all winter, set in cages in the field the following summer, and carefully watched. Each September the plants and the year's work are thrown away because in all the plants surviving the treatment, the virus also survived.

After a few dozen experiences like these, one will not be too downcast at a little difficulty like the one we encountered last month. My colleague, Dr. J. C. Bushman, of the English Department, and I planned a little experiment in coordinating Rhetoric 1 with the elementary course in botany for agriculture students. Nothing appeared easier than to pick two good sections, a total of 50 students, from our probable class of 150. When we actually came to choose our students however it developed that half of the 150 had failed the proficiency test and were taking Rhetoric 0, a non-credit course in the elements of composition. A lot more had taken Rhetoric 1 the previous summer and still others had passed a high proficiency test and were taking Rhetoric 2. Still others had conflicts. The result was less than 34 possible subjects for our experiment.

If I seem to speak with more than usual warmth, it may be because of some recent experiences. I prefer to pass over in silence the result of my attempt to introduce a new point of view in teaching by borrowing experienced teachers from other institutions. Instead I will retell an incident so trivial that even those closest to it could see the joke. About two weeks ago Dr. Bushman, already mentioned, raised a question regarding vocabulary. It was a very specific question and had to do with the ability of a rather special group of students to get information from a particular text.

Faced with a similar question regarding plants—whether a particular variety was able to absorb maximum nutrients from a given solution—the procedure would have been about as follows: first an examination of the facts available; then the planning of a controlled experiment to determine whether some better solution for this particular variety could be prepared. Actually, however, the behavior of the person most interested was quite otherwise. It began with *talks* with other *teachers* in an endeavor to discover what different *opinions* they held regarding the general proposition of vocabularies in elementary textbooks.

After such experiences as I have related, how can I have any

faith in experiments in teaching? But faith, as you all know, "is the substance of things hoped for, the evidence of things not seen." In this case my faith is buoyed up by the belief that the undertaking is exceedingly worthwhile and that in experimentation and only in it is there any real hope of progress and eventual, if partial, agreement.

I realize that in such experiments we will have to attempt to interpret results far below the conventional level of accuracy, even for students of living things. I have, however, already placed on record my belief that the importance of the problem, rather than the attainable degree of accuracy should be the criterion as to what problems should be undertaken. I could quote and have quoted[2] distinguished names in fields so diverse as astronomy and sociology in support of this thesis. For the present occasion, I shall quote only one: George Sarton (*The Study of the History of Science*), "No scientist worth his salt has ever abandoned an investigation simply because the attainable precision was too low."

[2] Stevens, N. E. Botanical research by unfashionable technics. Science, 93: 2408:172–176. 1941.

EDUCATION IN CHILE

A new bulletin, one of a series of basic studies on education in various Central and South American countries, issued as part of a program to encourage cooperation in the field of Inter-American education, was announced today by the U. S. Office of Education, Federal Security Agency.

Education in Chile, Bulletin 1945, No. 10, is a 123-page study based on data gathered in Chile in 1944 and supplemented through documentation. It was prepared by the Office of Education under the sponsorship of the Interdepartmental Committee on Cultural and Scientific Cooperation. The project, a part of a Government-wide program of cultural cooperation under the auspices of the Department of State, was begun in the fall of 1943. The author is Cameron D. Ebaugh, Senior Specialist in Education in Latin American Countries, Division of International Educational Relations, U. S. Office of Education.

The bulletin begins with a description of Chile as a nation today, and follows in detail the evolution of its educational system from early colonial days to its present status under a republican form of government. Various chapters are devoted to discussions of elementary education, the Chilean teacher, secondary education, vocational education, higher education, and institutions of higher education. Supplementing the text are 32 tables showing registrations, enrollments, and programs and plans of studies. Also included are bibliographies of Spanish and English references for further study.

Educators desirous of adding to their knowledge of educational methods in other countries will find *Education in Chile*, Bulletin 1945, No. 10, an interesting document. Copies may be obtained by purchase at 25 cents each from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG
Hyde Park High School, Chicago

106. The Order of Operations. On an average of once a month a teacher writes me asking whether $24 \div 2 \times 3$, or some similar expression, equals 4 or 36. He usually quotes the rule: Multiplications and divisions should be performed in the order in which they occur. According to this rule, the value of the preceding expression is 36. I do not agree.

Consider a rectangular solid for which $l=2$, $w=3$, $h=4$. Then evidently $V=24$.

Let us next reverse the problem and find h knowing that $V=24$, $l=2$, and $w=3$.

Since $V=lwh$ it follows that $h=V/lw$ which can also be written as $h=V \div l \times w$.

Since we know that $h=4$, we see that the multiplication must be done first, not the division, and the above rule is poorly stated. A correct statement would be: Do all the multiplications first; then do all the divisions; finally, do the additions and subtractions. Further, this rule is not the result of a meeting of mathematicians at which a vote was taken; the rule must be consistent with other mathematical terms and operations.

In an expression like $24 \div 2 \times 3 + 18 \div 9 \times 6$ we may, if we choose, find 9×6 before finding 2×3, thus disregarding the words "in the order in which they occur." But in an expression like $24 \div 8 \div 4$ these words would mean that we must first find $24 \div 8$ and then divide by 4, giving $\frac{3}{4}$ as the final value. If we first find $8 \div 4$, then the value of this expression is 12. We can tests the two answers by trying a problem which gives rise to the expression.

The equation $ab=cd$ is satisfied by $a=12$, $b=8$, $c=24$, and $d=4$. Further,

$$a=\frac{cd}{b}=c \times \frac{d}{b}=c \div \frac{b}{d}=c \div b \div d.$$

Then $a=24 \div 8 \div 4$, and we can get the correct value of a only by dividing 8 by 4 *first*, thus contradicting the phrase "in the order in which they occur."

The safest conclusions to reach from these examples are:

1. Use parentheses to indicate which operation should be performed first.
2. Do not write cd/b as $c \div b \div d$.
3. Investigate the problem which leads to the embarrassing expression.
4. In the absence of parentheses and other information, regard these expressions as "catch" questions and use the rule: Perform the multiplications first; then perform the divisions in the order in which they occur. If contradictions arise, remember that the problem is a "catch."

Incidentally, it is interesting to note that, according to the rule, $16 \div 8 \div 4$ and $16 \div 8 \times 4$ both equal $\frac{1}{2}$.

107. Varying the Method. It is easy for pupils to get the idea that there is only one correct way to solve an equation. If there are denominators, they first use a suitable multiplier to eliminate fractions; if there are parentheses, they at once multiply; then all terms involving x are collected in the left member (why always the *left* member?). And finally, if the teacher insists, there is the check by substituting in the given equation. To counteract this mechanical work it is well to introduce some variety in the class. And there is no better check than a second solution obtained by a different method.

Most pupils solve $5(x-3)=48$ by first multiplying $x-3$ by 5; but the equation can just as well be solved by dividing by 5.

To solve $ax+b=c$ most pupils first transpose b and then divide by a. A good check can be had by first dividing by a and then transposing.

To solve $x/a=b/c$ pupils multlply by ac but it is easier to multiply only by a.

To solve

$$\frac{x}{a}-\frac{1}{a+b}=\frac{x}{b}-\frac{1}{a-b}$$

most pupils multiply by $ab(a+b)\ (a-b)$, but transposing two of the terms first and then doing some adding will shorten the work.

To solve

$$\frac{x}{x-2}-\frac{x+1}{x-1}=\frac{x-8}{x-6}-\frac{x-9}{x-7}$$

by first clearing of fractions is more difficult than first adding in each member.

An equation like $5x^{-1/2}=3$ should be solved in every possible way to get a good appreciation of exponents.

Not many of the verbal problems can be solved in a variety of ways, but consider:

How many ounces of metal that is 65% copper should be mixed with some metal that is 40% copper to make 75 ounces that is 55% copper?

An equation can be formed by using the relation: the amount of copper in the first metal plus the amount of copper in the second metal equals the amount of copper in the final mixture. But an equation can also be found by using: the amount of impurity in the first metal plus the amount of impurity in the second metal equals the amount of impurity in the final mixture. The two equations are:

$$.65x+.40(75-x)=.55\times 75,$$

$$.35x+.60(75-x)=.45\times 75.$$

I cannot explain *why*, but pupils are always surprised that it is possible to find the amount of *copper* by writing an equation which deals not with copper but with the part that is *not* copper.

And pupils are always greatly surprised when I solve an equation like $65x+40(75-x)=55\times 75$ as follows:

There are 55 seventy fives in the right member and only 40 seventy fives in the left member; hence the right member has an excess of 15 seventy fives. The left member has really only 25 x's. Hence $25x=15\times 75$ or $x=3\times 15$ or 45.

108. Choosing our Words. One would expect that mathematicians would be inclined to use numbers as much as possible in stating ideas, but there are many instances in our textbooks where we seem to be shy about using numbers. Why should we say that two angles are complementary if their sum is a right angle? We could better say "if their sum is 90 degrees." And two angles should be supplementary if their sum is 180 degrees, not if their sum is a straight angle. The sum of the angles of a triangle should first, last, and always be 180 degrees, not a straight angle. The area of a sphere should be $4\pi r^2$ and not the product of a diameter and the circumference of a great circle. The polar distance of a great circle should be 90 degrees not a quadrant. The area of a spherical triangle should not be its spherical excess but the sum of the angles minus 180. Private Hargrove has called attention to the fact that in army slang

"by the numbers" means with precision and exactness and the utmost efficiency.

There are some other old fashioned expressions that should be discontinued. Fifty years ago a point "without" a circle meant a point "outside" a circle; now the phrase sounds as if the figure is lacking a circle or that the pupil is prohibited from using a circle.

Perpendiculars should be drawn not "dropped"; likewise, arcs are drawn not "struck."

When factoring $ax+bx$ we should neither "take out" nor "factor out" the number x. I prefer to say merely that x is a common factor.

I do not object to removing parentheses since that is a grammatically correct expression. Neither do I object to "transposing" which is grammatically correct and a mathematical operation. But the prize for carelessness goes to the expression "Equals plus equals equal equals" when the pupil means "If equals are added to equals, the sums are equal." Here the emphasis should be on the word *sums*; obviously equal quantities will always be equal regardless of what we do to them.

109. Stimulating the Pupil. There may be various good ways of making a class work harder and put forth greater efforts, but I have never found one that produced better results than merely posting the results of all examinations on a bulletin board. In all my third and fourth year classes we have a 15 minute test once a week, and the results are put on the bulletin board where all may see them. That is all there is to the method. When I feel that a freshman or sophomore class is loafing, I use the same method.

We must stop thinking that the happy life is the life of least effort, and that the aim of mankind is to get the greatest return from the least effort. The aim of man is to improve himself. That is his sole purpose on this earth—to improve himself and his kind.—Dorothy Thompson.

In our country, as everywhere else, it will be found that, in the long run, ignorant voters are powder and ball for demagogues. . . . The unvarying testimony of history is, that the nations which win the most renowned victories in peace and war are those which provide ample means of popular education.—Rutherford B. Hayes.

A handful of good life is worth a bushel of learning.—*George Herbert.*

PAST PRESIDENTS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INCORPORATED

Compiled by EDWIN W. SCHREIBER, *Historian*

1902, 03, 04 *Charles H. Smith, (P) d.26, Hyde Park High School, Chicago, E05-26.
05, 06 Otis W. Caldwell, (B) State Normal School, Charleston, Ill.
07 Clarence E. Comstock, (M) Bradley Polytechnic Inst., Peoria, Ill.
08 *Franklin T. Jones, (P) d.43, University School, Cleveland, Ohio.
09, 10 *James H. Smith, (ES) d.37, Austin High School, Chicago, D29, 30.
11, 12 *Herbert E. Cobb, (M) d.38, Lewis Institute, Chicago.
13 *James F. Millis, (M) d.17, Francis W. Parker School, Chicago, S-T10, 11.
14 Willis E. Tower, (P) Englewood High School, Chicago, S-T08, 09.
15 *Chauncey E. Spicer, (P) d.43, Joliet Twn. High School, Ill., AS-T11, S-T12, T13.
16 Herbert R. Smith, (C) Lake View High School, Chicago, T14, 15, D28, 29, 30, 31.
17 E. Marie Gugle, (M) Assistant Supt., Columbus, Ohio, VP14.
18 Harry D. Abells, (C) Morgan Park Military Academy, Chicago, VP17.
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20 J. Albert Foberg, (M) Crane Technical High School, Chicago.
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22 Alfred Davis, (M) Soldon High School, St. Louis, Mo.
23 Frank B. Wade, (C) Shortridge High School, Indianapolis, Ind.
24 *Clarence Lee Holtzman, (B) d.31, Waller High School, Chicago, VP25.
25 *Elliott R. Downing, (B) d.44, School of Edu., Univ. of Chicago, D28.
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29 *Ada L. Weckel, (B) d.45, Oak Park High School, CS22, S25, 26, D28, 30, 31.
30 Walter G. Gingery, (M) George Washington High School, Indianapolis, Ind., T24, 25, 26, 27, D29, VP29, D32, 33, 34, 35, 36, 37.
31 Glen W. Warner, (P) Crane Jr. College, Chicago, S21, 22, 23, 24, B26-D29, 30, HM41-.
32 Franklin R. Bemisderfor, (C) East Tech. High School, Cleveland, D30, 31.

33 *Charles A. Stone, (M) d.44, University High School, Chicago, VP32.

34, 35 Katharine Ulrich (Mrs. J. Isenberger), (G) Oak Park High School, Ill. CS24, VP31, D32, 33, 36.

36 O. D. Frank, (B) School of Edu., Univ. of Chicago, D32, 33, 34, 35, 37.

37 W. R. Teeters, (C) Board of Edu., St. Louis, Mo., D34, 35, 36, 38, 39, 40, 41.

38 Ira C. Davis, (C) Univ. High School, Madison, AT24, 25, D33, 34, 35, 37, 39.

39 Marie Sangernebo Wilcox, (M) Washington High School, Indianapolis, AS30, D35, 36, 37, 38, 40.

40 Nathan A. Neal, (GS) James Ford Rhodes High School, Cleveland, Ohio, D36, 37, 38, VP39, D41.

41 Harold H. Metcalf, (C) Oak Park High School, S-T37, 38, S39, 40, D42, S43-.

42 Joel S. Georges, (M) Wright Jr. College, Chicago, D35, 36, 37, 38, 39, 40, 43.

43 George K. Peterson, (C) North High School, Sheboygan, Wis. D40, 41, 42, 44.

44 Emil L. Massey, (GS) Board of Education, Detroit, Mich., D41, 42, 43, 45.

* Deceased. The institution given is that at time of presidency.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. N. Jamison, State Teachers College, Kirksville, Missouri..

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1927, 32. Walter R. Talbot, Jefferson City, Mo.

1938. Wm. B. Hancy, Augusta, Maine; Daniel Pratt, Savannah, Ga.; G. W. Rolison, Alfred, N. Y.; Mabel Wilcox, Boston, Mass.

1939. *Proposed by Sol Whitman.*

Solve for b:

$$\frac{10}{\sqrt{400-b^2}}+\frac{10}{\sqrt{900-b^2}}=1.$$

Solution by Helen M. Scott, Baltimore, Md.

Let $a=10$; $x=900-b^2$; $y=400-b^2$.

$$y=x-5a^2 \tag{1}$$

$$a\sqrt{x}+a\sqrt{y}=\sqrt{xy} \tag{2}$$

$$a\sqrt{x}+a\sqrt{x-5a^2}=\sqrt{x(x-5a^2)}. \tag{3}$$

Squaring twice reduces (3) to

$$x^4-14a^2x^3+55a^4x^2-50a^6x+25a^8=0. \tag{4}$$

Inserting the value of a, one can solve the resulting equation, approximately by Horner's method.

$$x^4-1400x^3+550{,}000x^2-50{,}000{,}000x+25{,}000{,}000=0 \tag{5}$$

$$x=748.418 \tag{6}$$

$$b^2=900-x=151.582 \tag{7}$$

$$b=12.312. \tag{8}$$

Solutions were also submitted by Jennie Holman, Geneva, N. Y. and Anna Porter, Dover, Del.; Hugo Brandt, Chicago.

1940. *Proposed by Rebecca Twining, East Varick, N. Y.*

The triangle whose vertices are the ends of one oblique side of a trapezoid and the mid point of the other equals in area to half the area of the trapezoid.

Solution by Mildred Hopkins, Kankakee, Ill.

The area of a trapezoid = median × altitude. Consider the triangle as it is divided into two triangles, $\triangle_1$, and $\triangle_2$, by the median of the trapezoid.

Area of $\triangle_1=\frac{1}{2}m(\frac{1}{2}h)$.
Area of $\triangle_2=\frac{1}{2}m(\frac{1}{2}h)$.
$\therefore$ Area of $\triangle=\frac{1}{2}mh$, which is half that of the area of the trapezoid.

Solutions were also offered by Joseph Lerner, New York; Hugo Brandt, Chicago; John P. Esposito, Chicago; Nathaniel Ball, Tarrytown, N. Y.; Maggie Yakeley, Butte, Mont.; Lerna Allen, Elmira, N. Y.; Helen M. Scott, Baltimore, Md.; Frank Hardenbrook, Finburn, N. Y.; Mamie Hawkes, Halifax, Nova Scotia; Josaphene Choate, Salt Lake City, Utah; Nellie Hicks, Portland, Me.; Walter Warne and Edith Warne, Sturgeon, Mo.; Georgia Burroughs, Charleston, S. C.; and the proposer.

1941. *Proposed by J. S. Miller, New Orleans, La.*

Solution by Joseph Lerner, New York

If the earth could spin fast enough for bodies at the equator to lose their weight entirely, how long would the day be, if the earth is a sphere at all time with radius of 209×10^5 ft.

For a body to lose weight at the equator, the centrifugal force has to be equal to the gravitational pull. So—

$$\frac{mv^2}{r}=mg \quad \text{and} \quad v=\sqrt{rg}.$$

The day, or the time of revolution of one circumference would be

$$T=\frac{2\pi r}{v}=\frac{2\pi r}{\sqrt{rg}}=\frac{2\pi(209\times 10^5)}{\sqrt{32\times 209\times 10^5}}=50\pi\sqrt{1045}$$

$$=5077.84662 \text{ seconds}$$

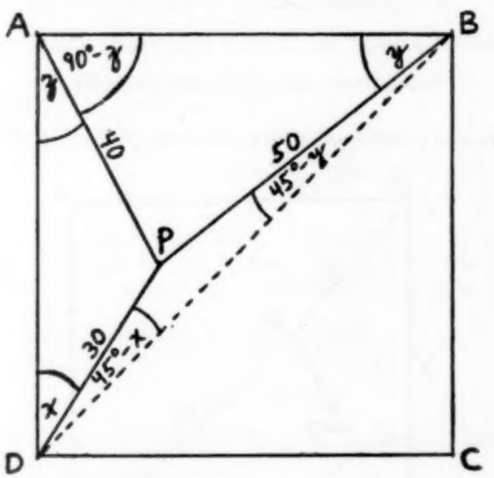
$$=1 \text{ hour, } 24 \text{ minutes, } 37.85 \text{ seconds.}$$

Solutions were also offered by Hugo Brandt, Chicago; Clarence R. Perisho, McCook, Nebr.; Gene Archer, Southern Methodist University; Helen M. Scott, Baltimore, Md.; and the proposer.

1942. *Proposed by B. Felix John, Philadelphia, Pa.*

A point P, is inside a square $ABCD$ and not on a diagonal if $PA=40$, $PB=50$, and $PD=30$, what is the area of the square?

First Solution by Aaron Buchman, Buffalo, New York



From the law of sines in triangle APD,

$$3 \sin x=4 \sin z. \tag{1}$$

From the law of sines in triangle APB,

$$5 \sin y=4 \sin (90°-z)=4 \cos z. \tag{2}$$

Squaring (1) and (2) and adding,

$$9 \sin^2 x+25 \sin^2 y=16. \tag{3}$$

Replacing $\sin k$ by $(1-\cos^2 k)$ in (3) and simplifying,

$$9 \cos^2 x+25 \cos^2 y=18. \tag{4}$$

From the law of sines in triangle DPB,

$$3 \sin (45° - x) = 5 \sin (45° - y). \tag{5}$$

Expanding the binomials in (5) and simplifying,

$$3(\cos x - \sin x) = 5(\cos y - \sin y) \tag{6}$$

or

$$3 \cos x - 5 \cos y = 3 \sin x - 5 \sin y. \tag{6a}$$

Squaring (6a), using (3) and (4), and simplifying,

$$15(\cos x \cos y - \sin x \sin y) = 1 \tag{7}$$

or

$$\cos (x+y) = \frac{1}{15}\cdot \tag{7a}$$

Thus

$$\sin (x+y) = \frac{\sqrt{224}}{15}\cdot \tag{8}$$

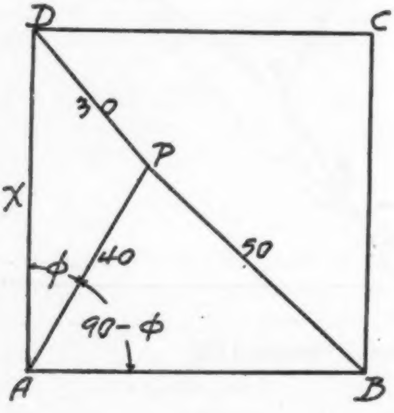
Now angle $DPB = 180° - (45 - x) - (45° - y) = 90° + x + y$.
Then from the law of cosine in triangle DPB,

$$2s^2 = 900 + 2500 - 2 \cdot 30 \cdot 50 \cdot \cos (90° + x + y). \tag{9}$$

Replacing $\cos(90° + x + y)$ by $-\sin(x+y)$, using (8), and simplifying,

$$s^2 = 1700 + 100\sqrt{224} = 1700 + 500\sqrt{14}.$$

Second Solution by Helen M. Scott, Baltimore, Md.



$$\cos \phi = \frac{40^2 + x^2 - 30^2}{80x} \tag{1}$$

$$\cos (90 - \phi) = \sin \phi = \frac{40^2 + x^2 - 50^2}{80x} \tag{2}$$

$$\sin^2 \phi + \cos^2 \phi = \left(\frac{x^2 - 900}{80x}\right)^2 + \left(\frac{x^2 + 700}{80x}\right)^2 = 1 \tag{3}$$

(3) reduces to

$$x^4-3400x^2+650{,}000=0 \tag{4}$$

$$x^2=1700+400\sqrt{14}. \tag{5}$$

For P outside the square

$$x^2=203.34. \tag{6}$$

Solutions were also offered by Mildred Hopkins, Kankakee, Ill.; B. Felix John, Philadelphia, Pa.; V. H. Paquet, Tigard, Ore.; Hugo Brandt, Chicago.

1943. *Proposed by William Cox, Willard, N. Y.*

If m and n are relatively prime, show that every odd division of m^2+n^2 is of the form $4k+1$, k an integer.

Solution by M. Schiffenbauer, Camp Wolters, Texas

Let

$$m=2x+1 \quad \text{or let} \quad m=2u+1$$
$$n=2y+1 \qquad\qquad n=2v.$$

Then $m^2+n^2=2(4k+1)$, where $k=x^2+x+y^2+y$ or $k=u^2+u+v^2$. Now an odd divisor of m^2+n^2 is a divisor of $4k+1$ and takes the form $4l+1$ or $4l-1$. Suppose $4l_1-1$ is a divisor with $4l_2-1$ the quotient. Hence

$$m^2+n^2=4k+1=(4l_1-1)(4l_2-1).$$

Since every odd number is the difference of two squares, we may write $4l_1-1=r^2-s^2$ and $4l_2-1=t^2-u^2$. Then

$$\begin{aligned} m^2+n^2&=(r^2-s^2)(t^2-u^2)\\ &=(rt\pm sa)^2-(st\pm ru)^2\\ &=4k+1. \end{aligned}$$

Thus under the assumption that $4l_1-1$ is a divisor of $4k+1$, we have $4k+1$ as the difference of two squares, which is contrary to the given relation m^2+n^2. Hence m^2+n^2 has odd factors of the form $4k+1$.

1944. *Proposed by Grace Smith, McDuffietown, N. Y.*

Solve for x:

$$\sqrt[4]{x}+\sqrt[4]{a+x}=\sqrt[4]{R}.$$

Solution by Mildred Hopkins, Kankakee, Ill.

Squaring both sides gives

$$\sqrt{x}+\sqrt{a-x}+2\sqrt[4]{x(a-x)}=\sqrt{R}. \tag{1}$$

By transposition,

$$2\sqrt[4]{x(a-x)}=\sqrt{R}-\sqrt{x}-\sqrt{a-x}.$$

Squaring both sides of this and collecting like terms gives

$$2\sqrt{x(a-x)}=R+a-2\sqrt{R}\,(\sqrt{x}+\sqrt{a-x}).$$

By substitution from equation (1), we got

$$2\sqrt{x(a-x)}-4\sqrt{R}\,\sqrt[4]{x(a-x)}-(a-R)=0.$$

By means of the quadratic formula,

$$\sqrt[4]{x(a-x)}=\sqrt{R}\pm\sqrt{\frac{R+a}{2}}.$$

$$\therefore\quad x(a-x)=\left[\sqrt{R}\pm\sqrt{\frac{R+a}{2}}\right]^4$$

$$\therefore\quad x=\frac{1}{2}\left[a\pm\sqrt{a^2-4\left[\sqrt{R}\pm\sqrt{\frac{R+a}{2}}\right]^4}\right].$$

Solutions were also submitted by Walter R. Warne, Sturgeon, Mo.; Hugo Brandt, Chicago; Milton Schiffenbauer, Camp Wolters, Tex.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in his department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1940. Hope Sabella, Convent Station, N. J. and Edwin Wallin Jr., Stevens Point, Wis.

EDITOR'S NOTE: It is again possible to send to a high school student, who has independently worked a problem and sent in a solution, a copy of the magazine showing this contribution. The teacher should certify the above stated conditions. A limited number of magazines are set aside or this purpose.

PROBLEMS FOR SOLUTION

1957. *Proposed by Howard D. Grossman, New York, N. Y.*

Find the length of the longest ladder that can be carried, parallel to the ground, around the corner of a corridor, where a is the width of one arm of the corridor and b is the width of the other.

1958. *Proposed by F. A. Bjorkland, San Diego, Calif.*

In right triangle ABC a square $CFDK$ is inscribed with D on the hypotenuse, AB. If each side of the square is 4, construct AB so that $AB=15$.

1959. *Proposed by Pvt. Milton Schiffenbauer, Camp Wolters, Texas*

Find two points of intersection of the curves;

$$y^2-y(x^2+x)+x^3+1=0$$
$$2y-x^2-x=0.$$

1960. *Proposed by Brother Felix John, Philadelphia, Pa.*

Given M and N, the mid points of the non parallad sides AB and CD respectively of the trapezoid $ABCD$. Also $MY\perp CD$ and $NX\perp AB$. Prove $NX/MY=CD/AB$.

1961. *Proposed by Brother Felix John, Philadelphia, Pa.*

Find a simple value for

$$\frac{(4+\sqrt{15})^{5/2}+(4-\sqrt{15})^{5/2}}{(6+\sqrt{35})^{5/2}-(6-\sqrt{35})^{5/2}}.$$

1962. *Proposed by Nellie Bishop, Seneca Falls, New York.*

In any plane triangle ABC prove that

$$\tan B = \frac{b \sin A}{C - b \cos A}.$$

BOOKS AND PAMPHLETS RECEIVED

Electronics Dictionary, by Nelson M. Cooke, Lt. Com., U.S.N. Executive Officer, Radio Materiel School, Naval Research Laboratory. Washington, D. C., and John Markus, Associate Editor, *Electronics* Cloth. Pages viii+433. 14×22.5 cm. 1945. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $5.00.

Principles of Radio for Operators, by Ralph Atherton, M.S. Assistant Professor of Physics, Miami University. Cloth. Pages x+344. 13×20.5 cm. 1945. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.75.

Atom Smashers, by Raymond F. Yates, Lockport, New York. Cloth, 182 pages. 14×22.5 cm. 1945. Didier Publishing Company, 660 Madison Avenue, New York 21, N. Y. Price $2.00.

An Introduction to Organic Chemistry, by the late Alexander Lowry, Ph.D., and Benjamin Harrow, Ph.D. Sixth Edition, Revised by Benjamin Harrow, Ph.D., Professor of Chemistry, and Percy M. Apfelbaum, Ph.D., Assistant Professor of Chemistry. Both at the City College, The College of the City of New York. Cloth. Pages xiv+448. 13.5×21.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.50.

Table of Arc Sin X, Prepared by the Mathematical Tables Project, Conducted under the Sponsorship of the National Bureau of Standards. Present Volume begun under the Auspices of the Work Projects Administration for the City of New York and Completed with the Support of the Office of Scientific Research and Development. Lyman J. Briggs, Director, National Bureau of Standards, Official Sponsor; and Arnold N. Lowan, Project Director, Mathematical Tables Project. Cloth. Pages xix+124. 18×26.5 cm. Columbia University Press, New York, N. Y. Price $3.50.

The Herbal of Rufinus, by Lynn Thorndike, Professor of History at Columbia University. Cloth. Pages xliii+476. 15×23 cm. 1945. University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $5.00.

Workbook with Laboratory Exercises for Use with Physics, by Elmer E. Burns, Teacher of Physics (Emeritus), Austin High School, Chicago; Frank L. Verwiebe, Associate Professor of Physics, Hamilton College, Research Associate Army Institute, Formerly Associate Professor of Physics, Eastern Illinois State Teachers College; and Herbert C. Hazel, Major, U. S. Marine Corps, Formerly Head of Science Department, Bloomington, Indiana High School, Assistant Professor of Physics, Indiana University. Paper. Pages iv+392. 17.5×27.5 cm. 1945. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.

Consumer Chemistry, Charts, exhibits, films, slides and filmslides, pictures, publications and recordings, edited by Sarah Bent Ransom, Instructor in Science, College High School and compiled by John Chiocca

and Robert van Reen from materials collected by Lili Heimers, Director, Teaching Aids Service of the Library, New Jersey State Teachers College at Montclair. Paper. Pages 4+iv+36. 21×28 cm. 1945. Price 75 cents

HEALTH EDUCATION, Charts, maps, and posters; exhibits; films, slides and filmslides; games; pictures, publications and recordings, compiled by Lili Heimers, Director, Teaching Aids Service of the Library and edited by Margaret G. Cook, Librarian, New Jersey State Teachers College, Upper Montclair, N. J. Paper. Pages v+36. 21×28 cm. 1945. Price 75 cents.

ROEMER AND THE FIRST DETERMINATION OF THE VELOCITY OF LIGHT, by I. Bernard Cohen, Department of Physics, Harvard University. Paper. Pages 63. 15×22 cm. 1944. Price $1.00.

HOW TO BUILD TERRAIN MODELS, prepared for the U. S. Office of Education, Washington by the United States Navy, Office of Research and Inventions, Navexos P-296. Paper. Pages 28. 15×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 10 cents.

RADIO HEAT, WHAT IT IS, HOW IT WORKS, WHAT IT CAN DO. Paper. Pages 23. 14×18 cm. Radio Corporation of America, Department of Information, 30 Rockefeller Plaza, New York 20, N. Y.

BOOK REVIEWS

ATOM SMASHERS, by Raymond F. Yates, *Lockport, New York*. Cloth. 182 pages. 14×22.5 cm. 1945. Didier Publishing Company, 660 Madison Avenue, New York 21, N. Y. Price $2.00.

This is a little book on a very live subject, told in about the simplest possible manner. Like all the other accounts now, it takes the reader up to the things he would like to know, but gives him no forbidden information. Starting way back in ancient Greece with the conflict between Democritus and Anaxagoras he takes us in a page or two through the ideas of Newton and Boyle, then Dalton, and clear on up to 1941 when "only ninety-two primary building blocks or atoms are known." In the second section we play that we shrink in size until we can get some idea of the fundamental parts of the atom: the electron, the positron, the neutron, and the proton. Chapter three gives just a brief sketch of the fundamentals of electricity. Now the sections of the book grow longer. The fourth division tells of the work of Crookes, J. J. Thomson, C. T. R. Wilson, the Curies, and Rutherford. The fifth deals with Millikan's oil drop and how it aided in determining the mass of the electron; with Rutherford's atom smashing experiments; with the young man Mosley, with Chadwick, the Joliots, Dirac, and Anderson. Chapter six is about the "engines of destruction"—the Van de Graaf machine and the cyclotron of E. O. Lawrence. The final chapter tells of the work of Fermi, and Nier, and Dunning just before the war which led up to the "Manhattan Project," the addition of two new elements to the Periodic Table, and to the atomic bomb. But to go farther is forbidden at present.

It is extremely unfortunate that so good a story should have been almost ruined by errors in many of the illustrations. The very first one gives Anderson's first picture of a positron but the explanation below says, "Thus when the electron or positron slows up, it will curve less." On page 54 is an

electrified rubber rod with positive charges. On page 69 are "tubes that had been evacuated of air and *filled* with another gas." (The italics are mine). On page 73 we have an *N*-pole apparently attracting a beam of electrons. But let us not be too critical. It is difficult for a scientist or a science writer to work fast. It is quite probable that Mr. Yates did not write the legends for the drawings. Get the book. It is worth the two dollars.

G. W. W.

RADIO DIRECTION FINDERS, by Donald S. Bond, *Radio Corporation, of America RCA Victor Division, Camden, New Jersey.* Cloth. Pages xii +287. 13×21 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y.

Although this treatise was written during the war years, it should continue to serve engineers as a textbook and reference work for peace time development of this most important aid to navigation. Heretofore, the material contained in this text was only available in the periodical literature of the past ten or fifteen years. Undoubtedly great strides were made in this field during the war, which were necessarily kept secret. The engineer should find this book an excellent background on which to add the newer developments as they are revealed in current articles.

The theory, design, and practical applications of direction finders to aircraft, shipboard, and fixed-station use are thoroughly covered. Each chapter is well fortified by a bibliography covering the material of the chapter. Footnote references are also given in definite substantiation of statements.

What the effect of radar will be on the peace-time development in this field, whether to augment it or render much of it obsolete, will depend upon engineering development in both fields.

H. R. VOORHEES

MORE ACIDS AND BASES, a collection of six papers recently published in the Journal of Chemical Education. Cloth 12.5×19.5 Cm. Pages VIII +79. Journal of Chemical Education, Easton, Pa. 1944.

This is in a sense a "sequel" to a similar series of articles published in book form in 1941. The earlier collection has aroused considerable interest among teachers and students of chemistry. The present volume is brought out to supplement that interest and to make available in convenient form a summary of the various viewpoints concerning acids and bases and their behavior.

The six articles are

(1) Acids and Bases in Organic Chemistry by David Davidson, Brooklyn College
(2) The Indicator Method of Classifying Acids and Bases in Qualitative Organic Analysis, by David Davidson, Brooklyn College
(3) Acids and Bases: Their Relationship to Oxidizing and Reducing Agents, by W. F. Luder, Northwestern University
(4) Teaching the Electronic Theory of Acids and Bases in the General Chemistry Course by W. F. Luder, W. S. McGuire, Saverio Zuffanti, Northwestern University
(5) Acid-Base Relationships at Higher Temperatures, by L. F. Audrieth and Therald Moeller, University of Illinois
(6) Acids and Bases: A critical Reëvaluation, by Robert Ginell, Polytechnic Institute of Brooklyn.

The importance of acids and bases and the various theories with which they are treated will commend this volume to the attention of chemists in general and to teachers and students in particular. Dr. Rakestraw, Editor of the *Journal of Chemical Education* is to be commended for making these excellent articles available in such a convenient form both for present use and for future reference.

B. S. HOPKINS

GENERAL CHEMISTRY, by John Arrend Timm, *Professor of Chemistry and Director of School of Science, Simmons College, formerly of Yale University*. Cloth. Pages xii+692. 14.5×22 cm. 75 tables, 184 illustrations. 1944. International Chemical Series. McGraw-Hill Book Co. 330 W. 42nd St., New York 18, N. Y.

This book is a typical college text book, not to be confused with the author's well known *Introduction to Chemistry*. The General Chemistry "is designed to meet the needs of those students who plan to use chemistry in their professional education and suitable also for use both by those who have had no previous course in chemistry and by those who have completed an elementary course in a secondary school." The author has endeavored to present a textbook which will not be too voluminous, but which will contain an adequate discussion of fundamental theories. These are usually given a brief historical approach and developed in a semi-conversational style, such as might be expected in the class room before a small group of students. Modern theories are used throughout. The fundamental facts concerning difficult topics are presented in an early chapter, with an amplification in some later part, in the belief that "repitition . . . is needed to fix fundamental principles in the student's mind." This spiral development makes it difficult to follow a logical scheme of arrangement of topics. In addition the author has included a liberal quantity of "those items, which although they may not be essential, are needed to add zest to the course and inspiration to the students." In order to keep the size of the book within bounds much material has been tabulated, especially that concerning the properties and uses of the metals and their alloys.

There are 55 short chapters, the last four of which are devoted to Organic Chemistry. Most of the chapters open with a brief introduction which is sometimes historical, sometimes explanatory, but always interesting. The chapters close with a short series of exercises and a few references to current literature, largely to readily accessible journals. The Appendix contains 12 tables; the inside front cover gives a table of the chemical elements with the symbols, atomic numbers and 1943 atomic weights; the inside back cover shows a copy of the Periodic Table in the extended form.

Careful attention has been paid to the mechanical features of the book. The binding has been excellently done, the type is clear and readable. The extra large type used to represent some of the structural formulas might be of questionable usefulness. Most of the half-tones are excellent and the line drawings have been carefully prepared. Few first edition errors are discernible.

B. S. HOPKINS

HOW TO SOLVE IT, by Dr. G. Polya, *Stanford University*. First edition. Cloth. Pages iv+204. 13×20 cm. 1945. Princeton University Press, Princeton, New Jersey. Price $2.50.

How to Solve It written by Dr. G. Polya, a research mathematician, presents a method of approach to problem solving which is applicable to scientific, engineering, and social problems.

The book is divided into three parts: I. *In the Classroom*—how to challenge curiosity and bring into play inventive faculties, making it possible to experience the triumph of discovery. II. *The Dialogue*—in which the teacher answers the questions of the students, and III. *A "Dictionary" of Heuristic*—containing 64 parts.

In Part One, Dr. Polya develops very cleverly the four steps to problem solving, namely, understanding the problem, devising a plan, carrying out the plan, and looking back. The author tells in simple and general terms the procedures of the mind in searching for a solution of problems by suggesting fundamental questions as, what is required? what is the unknown? what are the conditions?, etc. Although the method of approach is applicable to many fields, the four steps are well illustrated by mathematical problems from geometry and calculus.

Part Two of the dialogue presents the same method of approach but in dialogue form in which the pupil asks the leading questions as, where do we start? what can I do? what can I gain by doing so?, etc., and the teacher proceeds to answer the questions in general terms which apply to all types of problems.

The Third and most extensive part is a short "Dictionary" of Heuristic. It contains 64 well developed definitions arranged alphabetically and including such terms as analogy, auxiliary elements, decomposing and recombining, Heuristic reasoning, induction and mathematical induction, pedantry and mastery, reductio ad absurdum and indirect proof, etc. The "Dictionary" is valuable reading although it may be used frequently as reference for information about a particular point.

DOYLE T. FRENCH
Elkhart, Indiana

PLANE AND SPHERICAL TRIGONOMETRY, by Frank M. Morgan, *Director of Clark School, Hanover, New Hampshire Formerly Assistant Professor of Mathematics, Dartmouth College.* Cloth. Pages v+247+lxxii. 14×21.5 cm. 1945. American Book Company, 88 Lexington Avenue, New York, N. Y. Price $2.50.

"This brief presentation of Plane and Spherical Trigonometry emphasizes the numerical aspect and gives as much of the theory as is necessary for a thorough preparation for further work in mathematics." These are the author's words about this book in the preface.

The book is divided into two sections, nine chapters (152 pages) of Plane Trigonometry, and five chapters (78 pages) of Spherical Trigonometry. There is also, for the benefit of the student who has not previously had them, a section on logarithms (13 pages). The book includes the topics that are usually placed in a course in trigonometry. Illustrations are numerous, and are placed so as to accomplish the maximum amount of good, and the many examples which are included to teach the student the "know how" of trigonometry are given in considerable detail. Checking is included as a regular part of the example and not as an extra. The arrangement of the subject material follows a logical pattern, those topics which are most important to the students' understanding of trigonometry being placed where he should be able to grasp and understand them.

There are approximately 1600 problems in the book, a sufficient number to permit the teacher to make allowances for individual differences in making assignments. The problems include many of a practical nature referring to such topics as mechanics, navigation, surveying, etc. There are several tests in the book, too, including mastery tests, true-false tests, and completion tests, as well as a long list of supplementary problems which may be used either for drill or testing.

Plane and Spherical Trigonometry appears to be well written, and I believe that the student who studies this book under the guidance of a competent teacher will not only have a better understanding but also a better appreciation of trigonometry and its importance in a modern scientific world.

ALBERT R. MAHIN
Hartford City High School

SONO-RADIO BUOYS LOCATED NAZI SUBMARINES UNDER WATER AND FOLLOWED THEIR COURSE

The story of the development of sono-radio buoys, that located Nazi submarines under the waters of the Atlantic and guided Allied destroyers to the spot for the kill, can now be told.

Visual and radar sighting served well as long as the enemy U-boats stayed on the surface but were of no value when the subs remained under water. The sono-radio buoy gave the airplane ears to hear, locate, and to follow a submerged U-boat.

The warned airplane could itself attack or call destroyers to the spot.

By relaying subsurface noises to the plane, the sono-radio buoy also made it possible to know the outcome of the attack. Sometimes the propeller beat of the U-boat as it fled the scene could be heard. Sometimes ominous break-up noises followed by silence testified to the death of the sub.

The sono-radio buoy, according to Dr. John T. Tate of the National Defense Research Committee, was a development of Division 6 of that committee, carried out under contract with Columbia University, Division of War Research, at the U. S. Navy Underwater Sound Laboratory at New London, Conn.

"The sono-radio buoy," Dr. Tate states, "was not a flash of genius springing from the brow of an inventor. Rather it was one of the results of purposefully bringing a group of trusted scientists and engineers into intimate and continuing contact with the progress and problems of U-boat warfare as it developed in the Atlantic."

The idea of the sono-radio buoy was not new, he said, but was taken from a heavy moored type of buoy, developed by the Naval Research Laboratory, for use in harbor protection where cable-connected hydrophones were not practical. But the adaptation to use a device of this sort from airplanes in U-boat warfare was new.

The problem was to develop a sono-radio buoy light enough to be carried in quantities by airplanes, cheap enough to be expendable, and rugged enough to withstand the shock of water entry. In addition it had to have battery-power sufficient for several hours' life, and adequate acoustic and radio range.

The floating sono-radio buoy picks up the sounds of a submerged U-boat by hydrophones which change the sound waves in the water into small electrical voltages which are amplified and converted into radio waves in the transmitter part of the buoy. Airplanes carried receivers tuned to the same frequency of the buoy transmitters.

Operators easily learned to distinguish between natural underwater sounds and foreign underwater noises. After locating an underwater craft and flashing word back to the destroyer base, the plane hovered over the spot and, by dropping additional buoys, followed the U-boat along its course.

WHY PHYSICS?

Marie Steffen

Immaculate Conception Academy, Dubuque, Iowa

"Why study *physics?*" students moan. . . .
Because its *principles* govern your home.
Just for a day check up your deeds
And see how often it fills your needs.

Early in the morning the alarm clock rings;
To your ears its *music*, a *sound wave*, brings.
Out you jump from your bed of feather,
Look at the *thermometer* and dress for the *weather*.

If it's early you switch on a *light;*
Laws of electricity show their might.
You turn on the faucet and find water there
Thanks to a *force pump* and *pressure* of *air*.

You take up a towel and wipe your skin—
The *law of capillarity* has just come in!
Now a final check-up in a *polished reflector*.
(How lost you'd be without this flaw detector.)

Molecules of food by *evaporation* come—
Down an *inclined plane* to breakfast you run.
You store up *energy* and *calories*, too—
For a full day's work is awaiting you.

The bus is waiting on the corner street.
Good for *gravity*—you stay on your feet.
The bus starts forward and back you go—
'Tis the *law of inertia* that gave that throw.

Time is precious, the *speed* increases,
Cohesion prevents your falling to pieces!
You arrive at school safe and whole
Just in time to answer the roll.

Same old schedule—regular classes—
The bell for *physics*,—how time passes!
In the laboratory you experiment and try
To find all the answers of *what* and *why????*

Sometimes it's difficult, but do your best;
Cover the *unit* and take the test.
The unpleasant results we shall omit,
But the grade you deserved you will admit.

See all we've met in a half a day;
And how much more there is to say.
Many a *principle* was overlooked—
Many are coming that shan't be booked.

The object, however, of this poor rhyme
Is to warn against a terrible crime
Of just using *physics* for the *physics class*,
Allowing natural miracles daily to pass.

Without an attempt ever to see
The reason for the mystery.
Come on, Students, wake up and live!
You'll get out of *physics* just what you give.

AIR-AGE EDUCATION

Air transportation is destined to play a vital, front line role in the social and economic planning of tomorrow. Educators have been quick to recognize the fact that the super air transports of today have shrunk distances to all points of the earth, bringing the peoples of the world, their social cultures, their technical information and their resources virtually to America's doorstep.

The changes in teaching brought about by this revision in the concept of distance has caused many school systems to inaugurate courses in aeronautics, either as a technical subject or as it applies to the everyday world as seen through the social sciences. To aid schools in organizing and conducting programs and courses for students, Transcontinental & Western Air, Inc., has established an Air-Age Education Service Center.

Dr. J. H. Furbay, widely known in education circles as an author, lecturer and teacher, and until recently a member of the staff of the United States office of Education, has been appointed to head the airline's new division.

With a thorough knowledge of modern teaching methods, Furbay will be able to assist teachers and their organizations in setting up and operating their own aeronautical programs. All activities of TWA's department will be closely coordinated with those of the Education Division of the federal government's Civil Aeronautics Administration.

Already under way as the first step in the 1945 program is a nation wide survey of the status and scope of Air-Age education and aeronautical training in the public school systems. Once the needs of the individual schools are determined, plans for comprehensive assistance can be formed, according to Furbay.

It is planted to offer a program for school students in every age group. A special course for elementary schools is being planned by Miss Carolyn Ogleson, until recently a teacher of air-age courses in the Piedmont, California, school system. The materials for high schools and universities will be more advanced, including special research on technical subjects and an emphasis on international aspects of aviation.

Maps, charts and photographs for understanding air-age geography; source materials on folk-customs and historical facts on areas that once were "far away" and now are only a matter of hours and minutes from the United States; visual aids and planned courses-of-study—all these will shortly be available to educational groups. Planning for the advanced groups includes institutes, summer courses and research projects that relate to the air-age program, and the establishment of educational tours both at home and abroad in cooperation with established travel agencies. Exhibits and lecturers for conventions, teacher-institutes and other educational gatherings will also be available.

Aluminum containers with a capacity of half a railroad box car are designed to be loaded in factories and transported by truck-trailer to the railroad track. They are shifted on or off a flat car with the aid of built-in hydraulic jacks and ball-bearing rollers.